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NEW YORK, JUNE, 1893.

EDITORIAL NOTES.

BRIDGE construction seems to be swinging around in a circle relative to the use of the old style of draw or lift bridge, which was, we believe, the original form that was given to bridges whose continuity was of necessity interrupted. There is a folding bridge at Chicago, and a big lifting railroad bridge at New York, and recent advices describe a new bridge over the Tiber at Rome, with a folding leaf for the central span, which is 41 ft. 7 in. in length.

WHILE the compound locomotive does not seem to have met with the enthusiastic reception in this country that its projectors expected and hoped for, it still continues to hold its own in Germany. At a recent meeting of the German Association of Engineers, the Chief of the Locomotive Department of the Prussian State Railways stated that the trials of the compound locomotive indicated its superiority over the single system, in that it did more work, saved fuel, and threw fewer sparks.

ENTHUSIASM is apt to run riot. Hardly has the *Campania* broken the record for the maiden voyage before the papers are publishing glowing accounts of the new White Star vessel of 700 ft., some even say 800 ft. in length, which is to make the passage from Queenstown to New York in four days and a half. It took a good many years to drop from six and a half days to a trifle less than six, and it is not at all probable that a full day is to be knocked off in a month or two. Record breaking is done by minutes just now.

AFTER a deal of trouble and some complaining on the part of inventors of magazine arms, the War Department has decided to allow the tests to be completed without any further interference. The removal of any officer of the board has been strenuously opposed on the ground that such a move would only result in confusion. It is also reported that the coming board will be instructed to pay particular attention to an examination of the inventions of Americans, with a view to supplanting the Krag-Jorgensen weapon.

NEWS comes from Ottawa that it is proposed to run a telephone line through from Halifax to Vancouver. The wire is to be of copper, and special long-distance instruments are to be used. We can hardly believe that such a project can be seriously contemplated, because the cost would be out of all proportion to the amount of business that would be obtainable. It sounds very much like a paper scheme, although the very fact that it is mooted indicates the enormous advancement that has been made in electrical matters within the past few years.

WITHIN the past few months we have illustrated a number of new systems of electric car-lighting that have been introduced in Europe. Up to the present time expense has militated so strongly against electric lighting that it has made no progress in this country; but these electricians are a determined set, and they will keep hammering away at the problem until it is solved. The latest road to make the trial is the Central of New Jersey, which is reported to be experimenting with a car equipped with 25 incandescent lamps.

NEW phases are continually developing in the Rapid Transit movement in New York. When the franchise was offered for sale there were no bidders; then the Commission began patching up for some sort of an arrangement with the Manhattan Elevated, and just as this was about to be consummated, Mr. Starin steps in and announces that a private company is ready to build the under-ground railroad, so the Manhattan contracts are held in abeyance while the people wait to learn whether there is anything in the new deal or not. Then, after a few days of discussion, the Board snddenly yields about all that the Manhattan asked for, and the latter plays coy with the demand for a payment of five per cent on the net profits of the road.

POTENTIAL CONTRIBUTORS.

IN some respects the lot of an editor of a technical paper, like that of a policeman, "is not a happy one," and it may be that analogous causes produce their respective infelicities, for the reason that omniprevalence is often expected of the policeman and omniscience of the editor. It need hardly be said that neither policemen nor editors come up to these high expectations. Of the duties of an editor it may be said in the words of St. Paul, "that tribulation worketh patience; and patience experience; and experience hope." The tribulation which he (the editor, not St. Paul) always has with him is the providing of matter for his paper which will interest and benefit his readers. The whole field of the specialty to which it is devoted is, of course, open to him. If that field embraces the science and art of mechanical engineering and railroad topics and interests, then, of course, whatever there is of interest and value relating to these subjects may supply material for its pages. To be of interest and of value, though, the material must be new. Now, an editor has the same difficulty in being intellectually omniprevalent that the policeman has in being physically so. It is impossible, however, to be mentally ubiquitous. The current literature of engineering—and the same is true of the literature of many other sciences and arts—is now so enormously great that no one person can keep

up any kind of intimate acquaintance with it. Then the practice of engineering is, of course, very much greater than the literature. An editor, therefore, naturally looks to contributors to supply material which, without such aid, it would be impossible for him to get. In his efforts in this direction he always encounters many and diverse and perplexing difficulties and obstacles. These it is thought are much greater than they should be, and to a very great extent are the consequence of misapprehension of those who are or might be valuable contributors. It is for this reason that the adjective which forms a part of the title of this article has been employed. "Potential," according to the dictionary meaning, "existing in possibility, not in actuality," and "endowed with energy adequate to a result." What we want to indicate is that there are many persons who might contribute valuable material to a publication like this, if they only had a clearer idea of what is needed, and also—if that be possible—how little value other kinds, especially second-hand, contributions have.

A dream which nearly all editors indulge in is that of having a host of contributors scattered all over the country, or—if they are more ambitious—all over the world, who will observe interesting events as they transpire, and report them to the editorial cognizance, which will thus form a perennial stream of "copy" to keep the journalistic wheels going.

It is an alluring dream, but like that of callow publishers, whose scheme for doubling their subscription list is the simple one of inducing each existing subscriber to send in another, it won't work; at least, it works only to such a very limited extent that it destroys its beautiful mathematical completeness, and fails utterly in accomplishing the grand object sought. Publishers are, however, in many ways like beggars, especially in this, that they prefer fractions of loaves to no bread, and are grateful to old subscribers—or any one else—for any new ones. So with an editor, while the scheme outlined above may not secure a ubiquitous host of contributors, it may be possible nevertheless to enlist the services here and there of persons who are careful observers, and who are willing to take the public into their confidence. It is with the hope of "endowing with energy adequate to a result" some who are valuable contributors in "possibility" that we are writing this article. To such it is proposed to give a few suggestions, some words of encouragement, and, if possible, stimulate them to share with the public some of the results of their experience and observation.

In the first place, it may be said that every contributor may be assured that, excepting perhaps to a very few intimate friends and relatives, his own personality is of no interest whatsoever. No one cares at all what you think or what you feel, but they may have the most intense interest in what you have seen. If you are writing for a technical paper, it should be done as though you were inexistent, or, at least, that you are without personal sensations or thoughts. Facts, entities, and phenomena interest the readers of a paper, but what occurs in that pulpy substance called your brain or that ossified organ, your heart, no one cares particularly about unless it be your wife, prospective or actual, your sisters, your cousins or your aunts; and they will pretend that they care more than they really do.

It is rare that what may be called a "subjective" article—that is, to quote the dictionary meaning of this word—one "especially pertaining to or derived from one's own consciousness, in distinction from external observation," is attractive to an editor or the readers of an engineering publication. Contributors should rather aim to make their contributions "objective"—that is, to quote the dictionary again, report "that which belongs to or proceeds from the object known, and not from the subject knowing, and thus denotes what is real, in opposition to that which is ideal—what exists in nature, in contrast to what exists merely in the thought of the individual."

As an example of what we mean, if the engineer on the New York Central Railroad who, it is said, recently ran a locomotive and train at a rate of over 100 miles an hour, would write out a minute account of how his locomotive acted during this run—that is, if he would tell such things as how the fire burned, how the boiler steamed, at what point of cut-off he worked the valve-gear, how high he carried water in the boiler, whether the engine rolled much, or if such a high speed could be maintained for any length of time, and if he would report other phenomena which he doubtless did or could have observed, and of which those of us who never ran an engine so fast know nothing about, such an article would be read with very great interest by many of our readers, whereas few of them, probably, would care much to know how he felt or what he thought, or whether he had a pain in his stomach, while his engine was running at that speed. For an intelligent report of the working of his engine we would be willing to pay liberally, whereas an account of his sensations, theories, and speculations about the engine would probably go into the waste-basket.

A very common but a very fatal defect of contributors is that of writing second-hand articles. This should be shunned with as much abhorrence as a person who aims to be well dressed would avoid buying second-hand clothes. A compilation from books or papers very seldom has much value as a contribution to a paper, for the reason that it is not new. Besides, the probability always is that the editor has access to the same and better sources of information than the contributor has. Encyclopædias, books, periodicals, papers, and reports to scientific societies are the tools with which an editor works. The chances, too, are that unless you are a specialist in that line, the editor to whom you send your contribution is better read in that line than you are. Because some book or paper is new to you, don't infer that it is new to all other people. A compilation is always more or less stale. Editors all know the slouchy contributor, who submits his badly written manuscript on some important subject, which an examination proves to be only a rehash—and usually a very poor one—of what the writer gleaned from easily accessible books and papers. There is always a miniature hell in editorial offices, to which such contributions are swiftly condemned with maledictions.

To be acceptable and valuable, contributions should be original. If they are descriptions or reports or observations of actual objects or events, they will always be so; if they are compilations, they never are. There is hardly a railroad, a machine shop, a ship, or an important structure of any kind anywhere which could not supply interesting material to a technical newspaper if reported by an intelligent observer. It might be only a few lines or a paragraph, but would be interesting, nevertheless.

Many persons are deterred from sending contributions to newspapers, because the data which they have or the observations they have made seem such very slight matters as not to be worth reporting. They always hold in reserve an intention of some day doing some great thing, which will

attract much attention and do them great credit. In the meanwhile they do nothing. If such people were inclined to be useful to their fellows in many little ways, the aggregate sum of their services would probably be much greater than it will be if they wait until the opportunity arrives for them to do some great thing.

Another deterring idea which often prevents those who might be valuable contributors from becoming so, is that they imagine that whatever is said or written for publication should be put into fine words and resounding sentences. Now, as a general thing the style of a contribution to a technical paper is of very little importance. The facts are the main thing. What the editor cares most about is that these are interesting and important and are correctly stated. The proof-reader will correct the spelling if it is shaky, and straighten out the grammar if it is at all tortuous.

Contributors, therefore, should not be too much concerned about the form of their contributions, excepting—especially if they are of considerable length—that what they send should be legible. Type-written copy has much to recommend it, and the facility with which it may be read may at times lead to the acceptance of an article, whereas, if an editor had to undergo the labor of deciphering illegible manuscript, the latter might be condemned to the perdition already referred to.

In composition, as in mechanics, there is a law of conservation of force, which Herbert Spencer formulated very clearly in one of his essays,* in which he says that the law underlying some of the current maxims about composition is "the importance of *economizing the reader's or hearer's attention.* To so present ideas that they may be apprehended with the least possible mental effort is the desideratum toward which most of the rules point. . . . Regarding language as an apparatus of symbols for conveying thought, we may say that, as in mechanical apparatus, the more simple and the better arranged its parts, the greater will be the effect produced. In either case, whatever force is absorbed by the machine is deducted from the result. A reader or listener has at each moment but a limited amount of mental power available. To recognize and interpret the symbols presented to him requires part of this power; to arrange and combine the images suggested by them requires a further part; and only that part which remains can be used for framing the thought expressed. Hence the more time and attention it takes to receive and understand each sentence, the less time and attention can be given to the contained idea, and the less vividly will that idea be conceived."

The potential contributor—for whom we have been writing—will therefore see that the general principles of mechanics are applicable to composition, and that the laws of thermodynamics have a controlling influence over words and ideas. Some one has given the general rule for composition, that the writer should know exactly what he wants to say and then say it. If he will do this so that the reader will have the least difficulty in understanding what has been written, he will be doing all that an editor of a technical paper is likely to demand.

The purpose of this article is, if possible, to induce more of our readers to note interesting observations, or observations of interesting events and phenomena, and to send them for publication. It is desirable that all imaginary barriers in the way of doing this should be removed, and that our potential contributors should feel the same, or greater, freedom in sending us information that they feel in communicating it to a friend, a cousin, or a brother. We want to divest "writing for the papers" of all formality and the greater part of the difficulties, most of which are imaginary, and to formulate a general invitation which will form a sort of a receptive vortex to draw to these pages the results of the observations of readers everywhere.

Editors, it is true, are like young women in this, that they can never part with the right of refusal, but neither of them can tell whether they will accept a contribution or a young man until it or he has been offered to them.

* The Philosophy of Style. Essays Scientific, Political and Speculative. Volume II.

CURRENT READING.

Marine Review.—This paper of May 11 blossoms out with a beautifully colored lithograph of one of the two twin-screw passenger steamships for the Northern Pacific Company, which are now building at the Globe Iron Works Company, of Cleveland, O. The paper contains 18 pages of reading matter. Besides other interesting material, an article relative to the Belleville boilers is contributed by Miers Coryell, the representative of the United States of the French owners of patents on this kind of steam generator. It should be added that these boilers have been installed in the new ships, of which our cotemporary gives an illustration. There is a general prosperous air about the pages of this last number of the *Review* which leads to an expression of congratulation.

BOOKS RECEIVED.

Knots, Splices, Hitches, Bends and Lashings, by F. R. Brainard, Ensign U. S. N. New York Practical Publishing Company.

Alternating Currents of Electricity, their Generation Measurement, Distribution, and Application. By Gisbert Kapp, C.E. The W. J. Johnston Company, Limited, New York.

Pumping Machinery. A Practical Hand-book relating to the Construction and Management of Steam Power Pumping Machines. By William M. Barr. Philadelphia, J. B. Lippincott Company.

The Coal Trade. A Compendium of Valuable Information relating to Coal Production, Prices, Transportation, etc., at Home and Abroad. By Frederick E. Saward, Editor of the *Coal Trade Journal*, New York.

Beeson's Inland Marine Directory. By Harvey C. Beeson, Detroit, Mich.

The Great Lakes Register of Shipping; also Rules and Tables of Scantlings for the Construction of Steel Ships. By Joseph R. Oldham, Cleveland, O.

Report of the United States National Museum, under the Direction of the Smithsonian Institute, for the Year ending June 30, 1890.

Annual Report of the Chief of Engineers, United States Army, to the Secretary of War, for the Year 1892. Four volumes and Atlas. Government Printing Office, Washington.

United States Geological Survey. J. W. Powell, Director: Mineral Resources of the United States, 1891. *David T. Day, Chief of Division of Mining Statistics and Technology.*

AMERICAN AND ENGLISH LOCOMOTIVES.

Our engravings this month represent the valve-gears of the two locomotives which have been the subject of this series of articles. The specifications of the American gear are very brief, and are as follows:

VALVE MOTION.

Approved shifting-link motion graduated to cut off equally at all points of the stroke. Links, sliding-blocks, plates, lifting-links, pins and eccentric-rod jaws of the best hammered iron, thoroughly case hardened.

Valve-face and steam chest seat raised above face of cylinder to allow for wear. Cylinders oiled from Nathan's No. 9 double sight lubricator placed in cab, with copper pipe under boiler lagging to steam-chest.

Valves, Richardson's balanced steam-chest valves.

Mr. Adams's specifications for the valve-gear of his engine is somewhat more full, but it will be seen is also quite brief.

VALVE MOTION.

The slide-valves are to be of the best Stone's bronze, to be made exactly as shown on drawings, and with recesses in its working face.

The valve-spindles and buckles are to be of the best Yorkshire iron, and of the dimensions shown on drawing. The spindles are to be guided by gun-metal glands and bushes through the steam-chest; the valve-spindle to be tapered where it enters the valve rod, and is to be secured by a cottar of mild Swedish steel.

The valve motion is to be of the curved link type, and the expansion links are to be hung from the center. The eccentric pulleys are to be in two parts, the smaller being of best Yorkshire iron, the larger of cylinder metal, and are to be fastened on the axle by means of keys and set screws, as shown. The eccentric straps are to be of good tough cast iron, free from honeycomb or any other defect. The throw of the eccentrics to be 6 in. The eccentric oil-cups are to be fitted with a button and spring. The eccentric rods are to be of the best Yorkshire iron, secured to the straps as shown. All the wrought-iron work is to be of best Yorkshire iron, the working parts to be well and properly case-hardened and re-cleaned up, and must be of the very best finish, and free from all marks and defects. All pins are to be of best Yorkshire iron, case-hardened, 2 in. diameter, and made to standard gauges. The motion is to be reversed by a screw-gear fixed on trailing splasher on right hand side of engine. The valve-rods are to work through cast-iron guides bolted to the motion plate.

The guides are to be bored out to fit the rods and to be made of cylinder metal, and to be provided with a lubricating box, as shown. The guides are to be heated to a high temperature and then dipped in oil.

One lubricator fixed on each side of smoke-box, with pipe leading to steam chest. One lubricator screwed into each front cover of cylinder. One oil-box and pipes, led down to top of each piston-rod, and valve spindle glands, and fixed as shown.

The principal dimensions of the two valve gears have been arranged in the following tabular form for convenience of comparison:

	American Engine.	English Engine.
Throw of eccentrics	5¼"	6"
Diameter of eccentric pulleys	16"	17"
Maximum travel of valve	5.68"	*
Outside lap of valve	1"	1"
Length of steam and exhaust ports	18"	16"
Width of steam ports	1¾"	1¾"
" " exhaust ports	2¾"	3"

From this table it will be seen that the proportions of the two gears do not differ very materially from each other. Either should give very good results. The principal differences are in the mechanical arrangement and construction of the various parts. In the American locomotive it will be seen that the valve-seats are outside of the frames, on top of the cylinders, and are horizontal. The movement of the eccentrics must, therefore, be transmitted to the valves by means of rock-shafts. In the English engine, on the other hand, the valve-seats are between the frames and on the sides of the cylinders and stand vertical. The arguments *pro* and *con* for the English arrangement are that the steam-chests are inside of the smoke-box, and are therefore to a certain extent jacketed, or kept warm, and therefore there is less loss of heat from radiation than there is if the chests are outside. It is the same argument which was used in favor of inside instead of outside cylinders. As long ago as when Clark wrote his book on "Railway Machinery," he concluded that it was possible to protect outside cylinders as well as those inside. The same thing is doubtless true of steam-chests. It is, of course, impossible to estimate the relative loss from condensation in steam-chests which are located outside, compared with that which occurs when they are inside. If, however, the conclusion which Clarke drew from his investigations, made nearly 40 years ago, and which has been confirmed by the practice in this country during that period, then there is little or no practical economical gain from having the steam-chests inside instead of outside, because they may be equally well protected in either location. It would be very interesting if some direct experimental light could be thrown on the subject, but it would be difficult, perhaps, to make such experiments conclusive. It might be possible to take two engines, as nearly alike as possible, one with inside steam-chests and the other with outside, and place both valves so as to cover the steam-ports. Then open the throttle-valves and let them each stand under steam for 24 hours, in cold weather, and make provisions for collecting the water condensed in the steam-chests. The relative amount would be an indication of the loss of heat in each.

It is argued in favor of placing the steam-chests on the sides of the cylinders, that it is then possible to make a direct connection between the link and the valve, and also that the link may be suspended symmetrically with suspension links on each side of it, whereas if the steam-chests are outside the connection must be made by means of a rock-shaft, and the link must be suspended unsymmetrically—that is, from one side only.

Now it is admitted that a rock-shaft, or "rocker," as it is generally called, is an additional member added to the valve-gear—that is, the American gear has two rockers and their two bearings in addition to the parts in the English gear. The latter, on the other hand, has a guide for the valve-stem, and two instead of one suspension link. It is admitted, too, that the first cost of the two rockers and their bearings is somewhat greater—but not much more—than that of the two guides and two suspension links of the English engine. There is no working part about a locomotive, however, which is as easy to maintain and costs so little as a rocker. It is safe to say that in ordinary practice they are not touched, for repair, on an average, once a year. Our English brethren seem to have an undue prejudice against rockers, considering how very little trouble they give to those who use them. It is true that they sometimes, though rarely, break, but when they do something ought to break, and it then costs less to replace the rocker than it would to renew some other parts which would be broken if the rocker was not.

Let us consider how much of a friend the maligned rocker is. It enables us to put the steam-chest outside with the valve-faces horizontal. In this position the steam chests, valves, valve-stems, valve-faces, stuffing-boxes, and oilers are all much more accessible and more conveniently located for repair than they are when they are between the cylinders and inside the smoke-box. Besides the valve-seats are horizontal, in which position they retain oil much better than they do if they occupy a vertical position.

On the New York Central & Hudson River Railroad it is not unusual, if an engine comes in at 10 o'clock in the morning with leaky valves, to take them out, reface them, and have the engine ready to go out at 7 o'clock in the evening. There is not a road in the country probably which does not, in cases of emergency, face up the valves and their seats over night. Can this be done with steam-chests located as they are in most English engines?

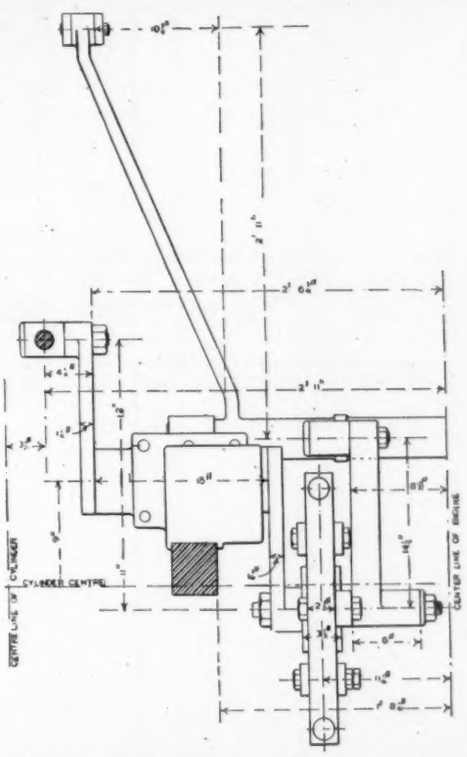
It will also be noticed that Mr. Adams's valve-yoke requires two guides, one at each end of the steam-chest. With the American form of construction only one, which forms the stuffing-box, is required. The valves of the English engine are made of bronze, which is the material generally used in Europe. Ours are universally cast iron. The extra cost of bronze and of the valve-stem guides will nearly or quite cover the extra cost of our maligned rockers.

We have no drawings of the oiling appliances for the cylinders and valves of the two engines, and cannot, therefore, form any idea of their relative cost, but from the specifications it will be seen that the valves and pistons of the American engine may be oiled from the cab by means of a Nathan sight-feed lubricator, while on the English engine the lubricators are fixed on each side of the smoke-box, and on each front cover of the cylinder. Apparently, then, there are four lubricators for oiling the valves and pistons, which require that the fireman should go to the front of the engine to apply the oil,

* As the eccentric rods are connected to the ends of the links, the travel of the valve is less than the throw of the eccentrics. Just how much this maximum travel is could not be ascertained by us excepting by an elaborate graphical construction.

whereas in the American engine one lubricator located in the cab does all the work. It is true that this is a double instrument, which is connected to each steam-chest, but it does all the work, and the lubrication can be done from the cab, without going to the front of the engine. Whether it would be practicable to oil the valves and pistons, which are located as the English valves are, with the means which are effective on our engines, we are unable to say, but if they could not be, it is thought that the slight extra cost of a pair of rockers is saved at a very considerable expense and inconvenience.

Something may also be said in favor of the method of fastening our cylinders together, which is practicable when the steam-chests are placed outside, but is not when they are inside. Cylinders for American locomotives are now almost universally cast with one-half of the intermediate saddle attached to each cylinder. To fasten them together all that is needed is to plane the surfaces of contact and bolt the two together. This makes a very stiff and rigid connection and fastening, and with suitable bolts, lugs and wedges on the frames, holds the cylinders so that they seldom work loose. It is questionable whether fastening cylinders to a plate-iron smoke-box and plate-iron frames will make as rigid and as secure connections as our method does. Our smoke-boxes consist of



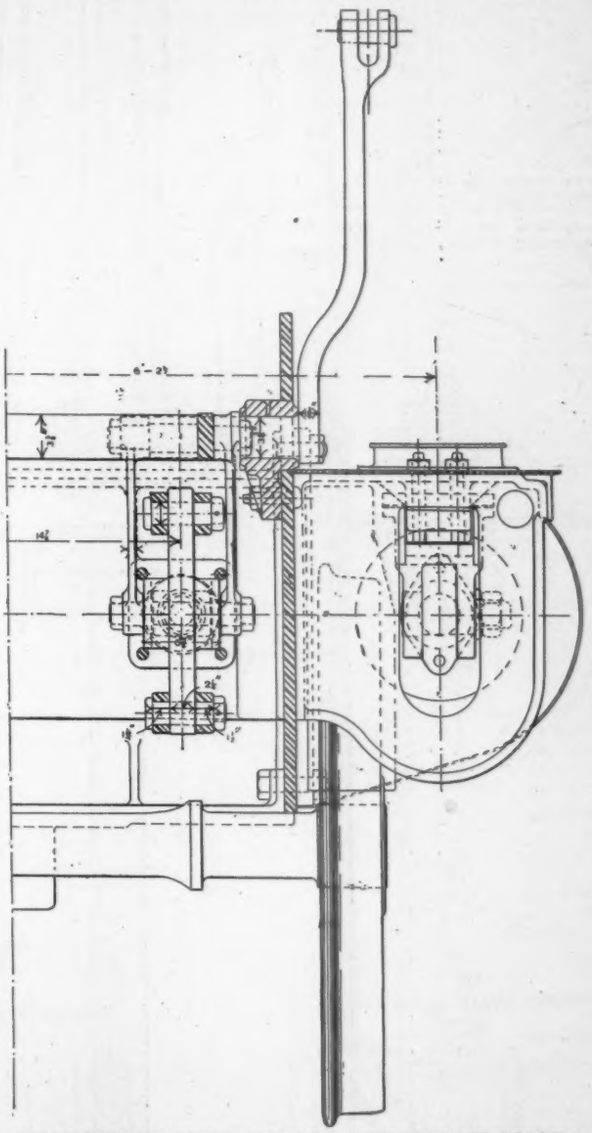
FRONT VIEW VALVE MOTION AMERICAN EXPRESS LOCOMOTIVE.

a simple plate rolled into a cylindrical form, with no flanging to it and little riveting. The English smoke-box is rectangular and is a more elaborate and costly structure, and the whole combination with the cylinders would appear to have less strength than ours.

Regarding the matter of suspending the links from each side, it will be admitted that this method satisfies a correct mechanical instinct better than the method which we are compelled to adopt when we use a rocker, and which compels us to use only one suspension link, which is attached to the inside of the link above. This gives a lop sided sort of support, and does not appear to be a good mechanical device. The bearings of the suspension link are made long and large on this account. It can be said, however, that very little practical difficulty is encountered in using this arrangement. The valve-gear of our locomotives, as it is now constructed, with ample bearing surfaces and with the balanced valves—which are now so generally used—costs very little to maintain. If the question were asked of most of our master mechanics whether they encountered any difficulties from the way the links on their engines are suspended, it is not certain that they would know what was meant by the question. The practical difficulty with this method of suspension is *nil*, which is indicated by its universal adoption on our locomotives.

It will be seen also that the eccentric-rods on the English engine are connected to the tops and bottoms of the links, instead of behind them, as is the American practice. With the former method it is impossible to lower the link so as to bring the rod opposite to the link-block. Consequently the latter and the valve stem do not get the full throw of the eccentrics. With our American links the rods can be brought up or down, so as to be opposite to the link-block, and they thus impart the full throw of the eccentrics to it. This accounts for the fact that the English eccentrics have so much more throw—6 in.—than those on the American engine, which have only 5¼ in. This necessitates the use of larger eccentrics and straps, which implies more weight and increased difficulty of lubrication.

In describing the driving-wheels and axles of the English engine, we called attention to the fact that the axles were

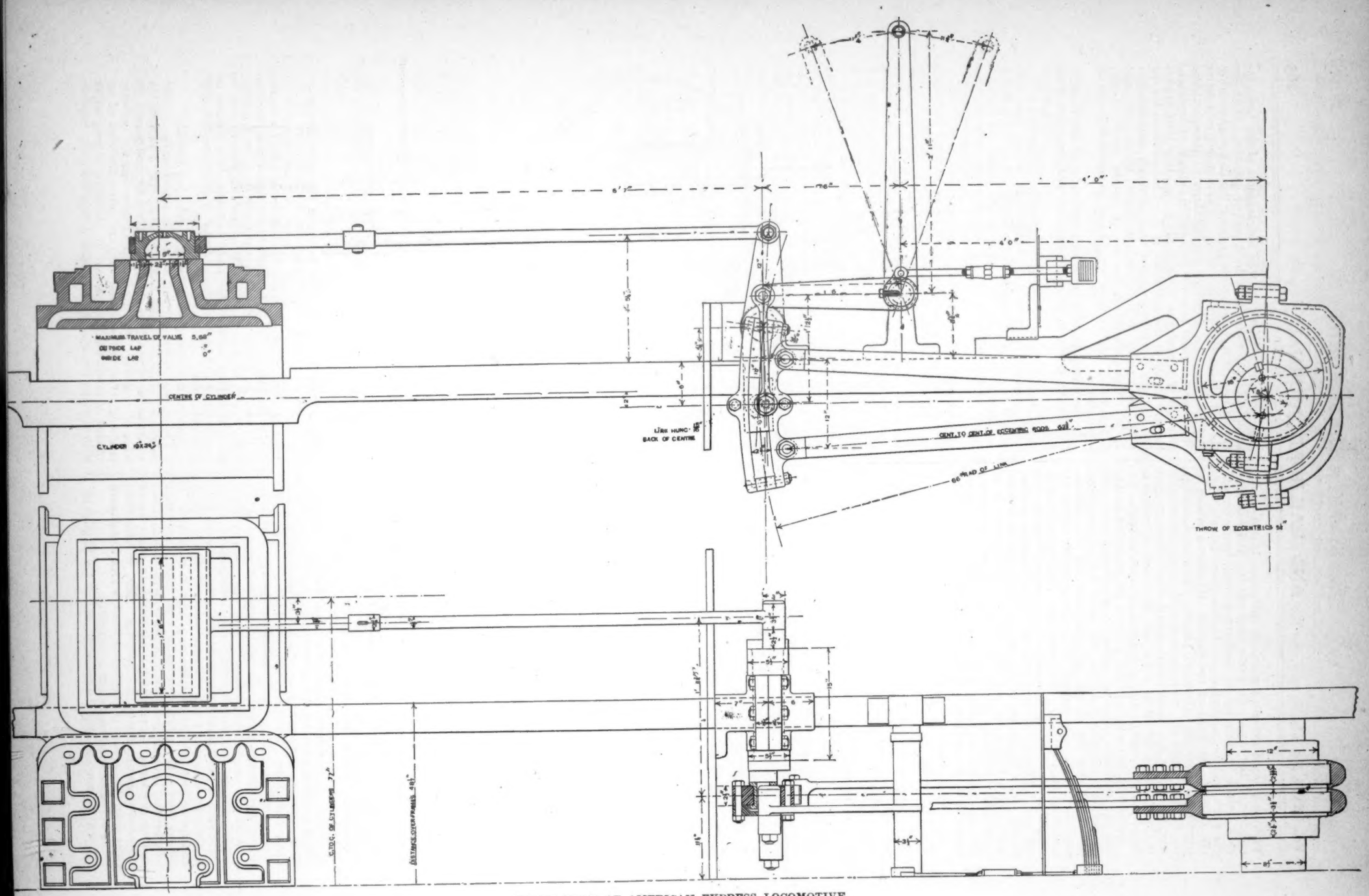


FRONT VIEW VALVE MOTION ENGLISH EXPRESS LOCOMOTIVE.

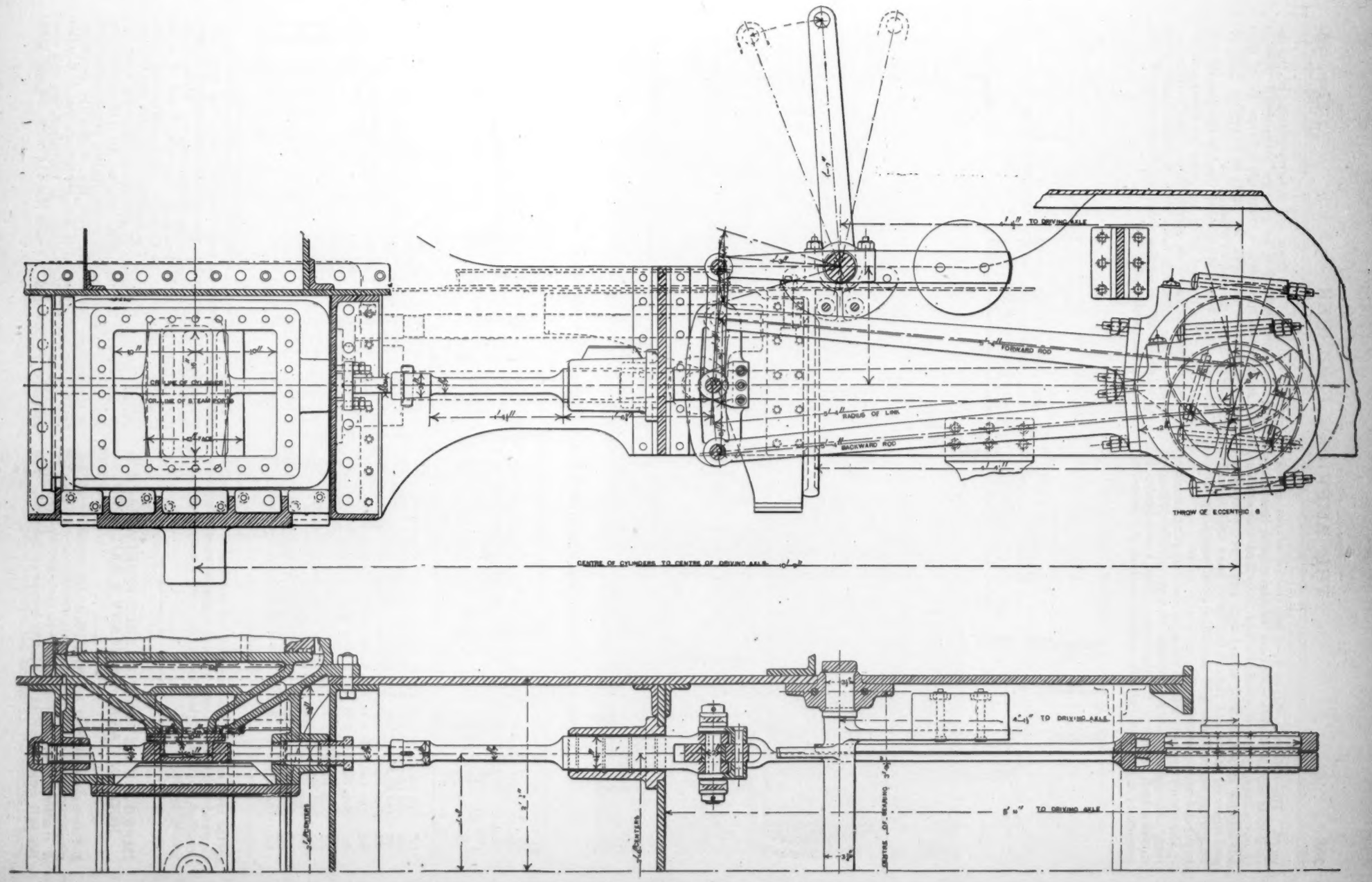
made of larger diameter in the wheel-seats than they were between the hubs. There is much to commend this practice, but from the engraving of the valve-gear and the specifications it will be seen that if this method of construction is adopted it then becomes necessary to make the eccentrics in two parts, which means greater first cost and some difficulty in maintenance.

Does the advantage of the enlarged axles pay for this?

The reverse levers are not shown in our engravings. Mr. Adams's engine has screw reversing-gear, which permits the valves to be adjusted to any point of cut-off, and lessens the labor of reversing. Mr. Buchanan's engine has the ordinary reversing lever, but with the balanced valves the labor of reversing is much diminished, and by providing a long sector with as many notches as practicable it supplies every require-


MAXIMUM TRAVEL OF VALVE 5.68"
OUTSIDE LAP
INSIDE LAP
CENTRE OF CYLINDER
CYLINDER 19X24
LINK HUNG BACK OF CENTRE
CENT. TO CENT. OF ECCENTRIC RODS 6'3"
66" RAD OF LINK
THROW OF ECCENTRICS 5½"
C. TO C. OF CYLINDERS 7'2"
DISTANCE COVER PLATES 4'8½"

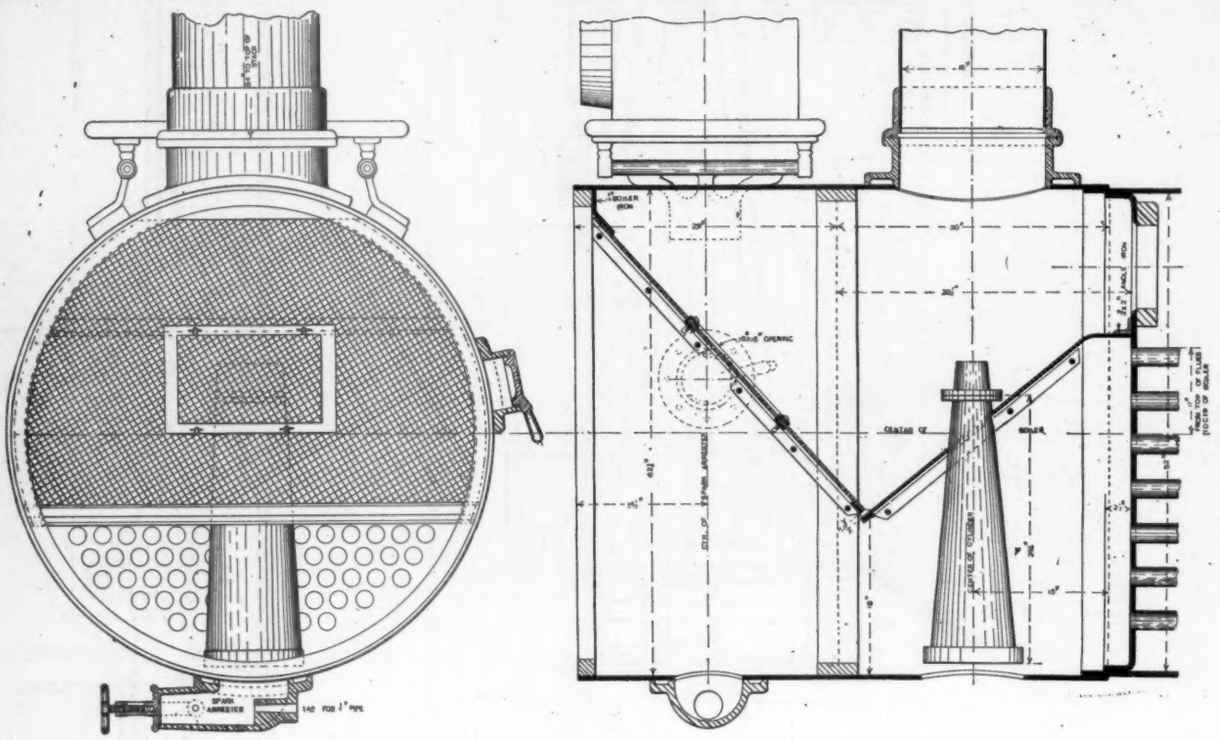
VALVE GEAR OF AMERICAN EXPRESS LOCOMOTIVE.



VALVE GEAR OF ENGLISH EXPRESS LOCOMOTIVE.

ment. The balanced valves have besides the advantage that they wear less than unbalanced valves, and require less power to move them. The algebraic sum of the advantages and disadvantages of unbalanced valves and screw reversing-gear, and balanced valves and the old-fashioned lever cannot easily be worked out on account of the difficulty of assigning values to the different elements.

The counterweights for the links are also deserving of attention. The foreign device consists of two cylindrical shaped castings each weighing 190 lbs. each. The American device consists of a light semi-elliptic spring attached to a short arm on the reverse-shaft. At least one bad accident is on record in England which was caused by such a counterweight becoming detached from an engine, and rolling under a train on an adjoining track.



SCHEDULE OF COAL CONSUMED BY DIFFERENT ENGINES WITH DIFFERENT DIAPHRAGMS.

No. of Engine.	Smoke Arch.	Cylinder.	Division.	Date of Test.	Points Between which Trip is Made.	No. of Miles.	No. of Train.	No. of Cars.	Schedule Time for Trip.	Coal per Trip in lbs.	Coal per Mile in lbs.	Coal per Hour in lbs.	Condition of Rail.	Remarks.	Miles per Ton of Coal.
205	Old Diaph.	19 × 24	A. & S.	Dec. 3	Troy to Binghamton.	151	1	7	7 25	10 200	67.5	1,374	Dry.	...	29.6
205	Old Diaph.	19 × 24	A. & S.	Dec. 4	Binghamton to Troy.	151	6	5	4.50	9 200	60 9	1,902	Dry.	...	32.8
202	Old Diaph.	19 × 24	A. & S.	Dec. 5	Albany to Binghamton.	143	7	5	4.55	8,350	58 3	1,698	Dry.	...	34.2
302	New Diaph.	19 × 24	A. & S.	Dec. 6	Albany to Binghamton.	143	7	4	4.55	4,500	31.4	912	Dry.	...	63.5
322	Pat. Austin.	18 × 24	A. & S.	Dec. 15	Troy to Binghamton.	165	3	4	5.20	6,425	38.9	1,200	Wet.	Allowing 14 miles to go to Albany Scales.	51.5
323	New Diaph.	18 × 24	A. & S.	Dec. 16	Troy to Binghamton.	165	3	4	5.20	4,900	29.6	918	Dry.	"	67.3
322	Pat. Austin.	18 × 24	A. & S.	Dec. 17	Troy to Binghamton.	165	3	5	5.20	5 500	33.3	1,036	Dry.	"	60.0
323	New Diaph.	18 × 24	A. & S.	Dec. 19	Troy to Binghamton.	165	3	4	5.20	4,350	26.3	810	Dry.	"	76.0
114	Old Diaph.	19 × 24	R. & S.	Dec. 7	Troy to Whitehall.	85	3	4	2.25	3,500	41.1	1,446	Dry.	"	48.6
113	New Diaph.	19 × 24	R. & S.	Dec. 23	Troy to Whitehall.	85	1	7	2.30	2,200	25.8	876	Dry.	"	77.2
113	New Diaph.	19 × 24	R. & S.	Dec. 23	Whitehall to Albany.	77	4	5	2.15	2,100	27.2	930	Dry.		73.3
210	Old Diaph.	19 × 24	R. & S.	Dec. 24	Troy to Whitehall.	85	1	7	2.30	3,000	35.2	1,200	Dry.	"	56.6
210	Old Diaph.	19 × 24	R. & S.	Dec. 24	Whitehall to Albany.	77	4	5	2.15	2,500	32.4	1,110	Dry.		60.8

IMPROVED EXTENSION FRONT, DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

THE extension front herewith illustrated is one which has given very remarkable results on the engines of the Delaware & Hudson Canal Company. It was designed by Mr. R. C. Blackall, Superintendent of Motive Power of the road. The principal feature of the front and the arrangement of the deflector-plate and netting is to give an unrestricted passage from the tubes to the stack, without the interposition of anything which tends to check the draft or to confine it to any one locality along the nest of tubes.

The engraving which we give illustrates the general construction very clearly, and all of the principal dimensions are so given that it would be an easy matter to duplicate its construction. The following table gives in details some of the tests to which this extension front has been subjected, with the results there obtained :

It may be well to call attention to a few of the figures given in this table, showing the improvements claimed to have been accomplished by the substitution of this diaphragm and front for the old arrangement, taking the two engines which made the run from Troy to Whitehall on December 7 and 23 as an example. The distance is 85 miles. Both engines had cylinders 19 in. × 24 in.. No. 114 hauling three cars and making a schedule time in 2 hours 25 minutes, and burning 3,500 lbs. of coal, or 41.1 lbs. per mile. Engine No. 113, making the same trip, hauling seven cars and occupying five minutes more in the passage, burned but 2,200 lbs., or 25.8 lbs. per mile, making the number of miles run per ton of coal 48 6 miles for 114, and 77.2 miles for 113. If we reduce this coal consumption to car-miles, we find that 114 with the old front

burned 10.27 lbs. per car-mile, while 113 burned only 3.7 lbs. per car-mile. Of course this difference is not claimed to be entirely due to the diaphragm when based on car mileage, because the engine in both cases had to be hauled. This comparison is taken at haphazard as we happened to glance at the table.

It will be seen by referring to the reports of engines 202 and 302, running December 5 and 6 from Albany to Binghamton, that the difference is almost if not quite as great. The average coal per mile for the old diaphragm was 58.3 lbs., whereas, with the new it dropped to 31.4 lbs. In each of these cases the condition of rail is scheduled as being dry. Men on the road say that the front keeps itself clean, and that cylinders are thoroughly churned up and can be readily blown out at the spark-arrester without any trouble.

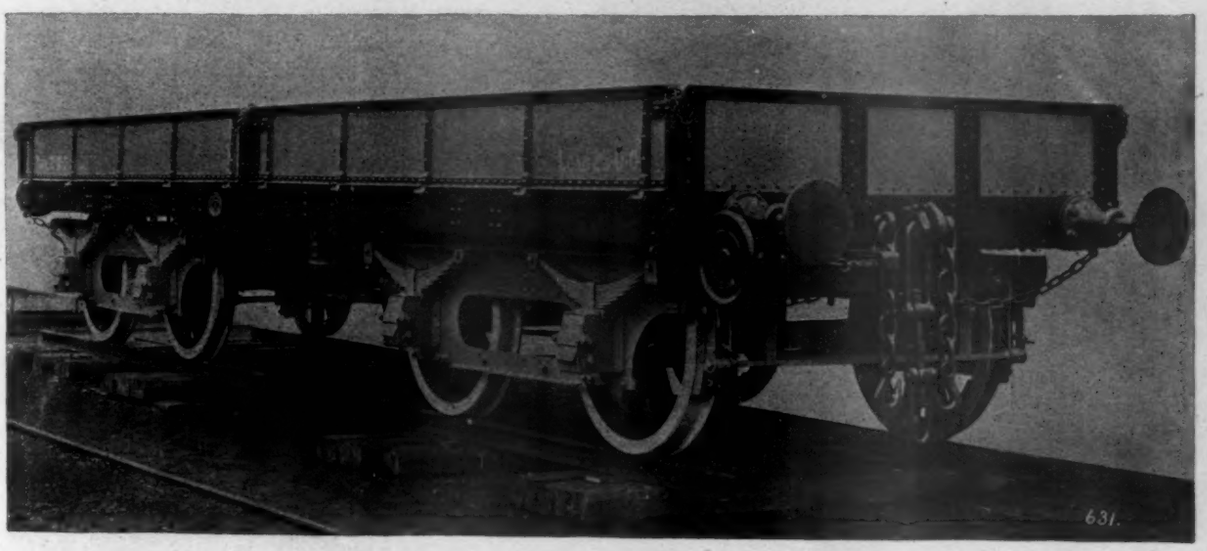
We regret that lack of space prevents us from illustrating more of the Delaware & Hudson appliances in this issue, but the matter will be continued in our July number, when we hope to show some more of their interesting hydraulic machinery.

The car is trussed with two truss-rods, each 1¼ in. in diameter, taking hold of straps riveted to the body bolster, which consists of two 9-in. channels with 3-in. flanges the same as those used for the sills.

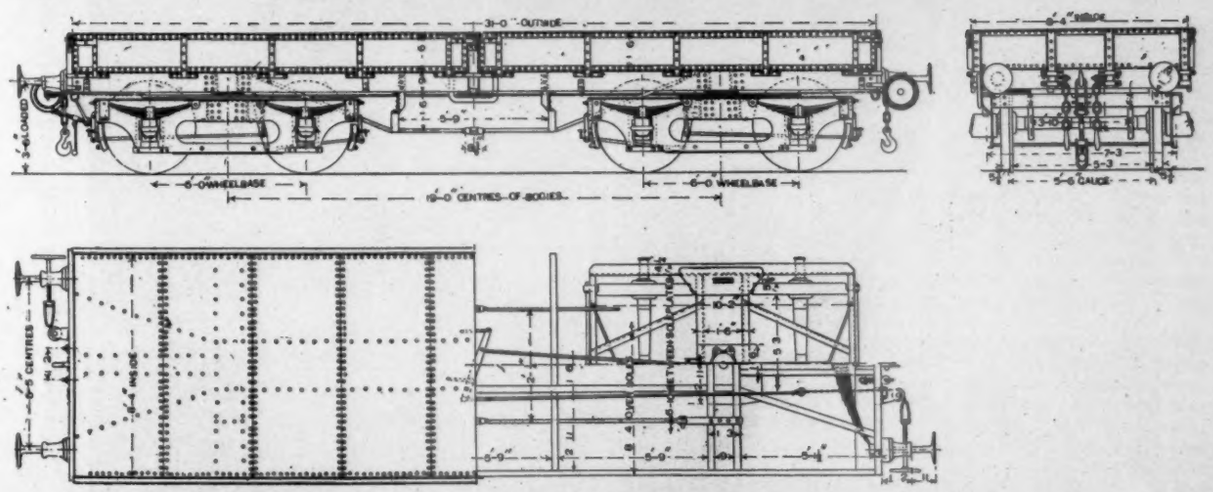
The width of body bolster over the flanges of the channels is 15 in., allowing a space of 9 in. between the two. This bolster is not trussed in any way, the strength of the car depending entirely upon the rigidity of the channels of which it is composed. The truck bolster is somewhat wider, but is composed of channels of the same size, which are spaced 18 in. apart.

The leading dimensions of the car are as follows:

Length over the buffers	35′ 2″
" " body	31′
" of under frame	31′
Width inside	8′ 4″
" of under frame	8′ 4″
Wheel base of each truck	6′
Total wheel base	25′
Center to center of box	19′
Height of floor from rail level	3′ 10 1/16″



CAR FOR CEYLON GOVERNMENT RAILWAYS.



ELEVATION AND PLAN OF BOGIE CAR FOR CEYLON GOVERNMENT RAILWAYS.

IRON FLAT CAR FOR THE CEYLON GOVERNMENT RAILWAYS.

We give a perspective view and a side elevation of a new iron car equipped with bogie trucks, which has recently been designed and built by the Lancaster Railway Carriage & Wagon Company, Lancaster, England, for the Ceylon Government railways. The truck framing is of the plate type, in accordance with the general character of English construction, and the sills are of 9-in. channels with 3-in. flanges. Of these sills there are four, the intermediate sills being spaced 16 in. apart.

Weight of under frame	7,900 lbs.
" " body	2,832 "
" " box	4,200 "
" " brake work	900 "
" " bearing springs	1,170 "
" " buffing springs	540 "
" " axle boxes	850 "
" " wheels and axles	6,834 "
Total weight of car	25,306 "

The wheels are 3 ft. 7 in. diameter on the tread, and the tires are 5⅛ in. wide over the flanges, the distance between the inside of the flanges of the wheels being 5 ft. 3 in.

The brakes are applied by a hand-wheel, as shown at the side of the car which sets the brakes on the outside of each

COMPOUND CONSOLIDATION LOCOMOTIVE, BUILT BY THE SCHENECTADY LOCOMOTIVE WORKS. COLUMBIAN EXPOSITION.

wheel. The arrangement of the brake is somewhat peculiar, inasmuch as it takes the screw form, as will be seen from the plan. When the brake is turned up, the clevis is drawn back toward the outside and the brake applied.

The general construction and arrangement of the car is very clearly shown by the engravings.

ITALIAN PROGRESS IN THE TRANSPORTATION OF FREIGHT.

THE Central Italian railways have introduced this year the American type of 30-ton freight cars with great success.

In commenting upon the subject, the Italian technical journal *Lavori Pubblici* says: "We have calculated the utility to be obtained by using these cars for carrying coal, basing our calculations on the quantity carried—*i.e.*, 1,152,975 tons from Genoa.

"With 12-ton cars at least 96,081 $\left(\frac{1,152,975}{12}\right)$ were employed, and as all were returned empty, and calculating the tare of each as 7½ tons, we find that the railways have transported a dead weight of $7\frac{1}{2} \times 2 \times 96,081 = 1,441,215$ tons, which added to paying load 1,152,975 tons, shows that the railways have carried a total gross weight of 2,594,190 tons.

"If this coal had been carried by the 30-ton cars, used as above, we would have obtained the following results: $\frac{1,152,975}{30}$ = 38,432 cars, the tare of which is 10 tons each, would have made the dead weight transported to and fro to have been:

$10 \times 2 \times 38,432 =$	768,640 tons.
To which add the paying load	1,152,976 "
Results in the railway having carried	1,921,916 "

"Therefore had these light-weight high-capacity cars been used last year carrying the same class of traffic, they would have effected a saving of the transportation of 672,575 tons. Calculating that on the Genoa line the gross weight of a train, excluding locomotive, does not exceed 300 tons, it results that the railway company would have saved $\frac{672,575}{300} = 2,261.91$ trains.

"The majority of this coal being for Milan and Turin, we will presume that these 2,262 trains would have run an average of 150 kilometers each; therefore, if a train kilometer costs the railway 3 lire for traction, we have a saving here of $2,262 \times 150 \times 3 = 1,017,900$ lire.

"This saving is in itself enormous, but to it must be added that with the 30-ton cars there would have been 86,868 less wheels and axles to care for, 57,649 less cars to register, each requiring two registrations, and an immense saving in wear, tear and lubrication, owing to the smoothness with which they run upon the tracks as compared with the rigid inflexible 4-wheeled wagons heretofore in use."

COMPOUND LOCOMOTIVE OF THE SCHENECTADY LOCOMOTIVE WORKS.

THE Schenectady Locomotive Works have on exhibition at the World's Fair four locomotives—a 10-wheeled passenger engine, 12-wheeled freight, six-wheeled switcher and a consolidation compound. We give a full-page illustration, taken from a photograph of the latter.

The general design of these engines has been very fully and completely illustrated, and most of our readers are familiar with their details. The dimensions and general features of the engine which we illustrate are as follows:

Fuel	Bituminous coal.
Gauge of road	4′ 8½″
Total weight in lbs.	149,000
Weight on drivers, in lbs.	132,000
" " truck, " "	17,000
Total wheel base	21′ 7″
Driving wheel base	14′
Rigid " "	14′
Cylinders, Diameter	R. H., 32″, L. H., 22″
Piston, stroke of	26″
" horizontal thickness of	4¾″ and 5¾″
" packing, kind	Cast-iron rings.
" rod, diameter	4″
" " packing, kind	U. S. metallic.
Steam ports, size	R. H., 21 × 2¾″; L. H., 19 × 2¾″
Exhaust ports, size	R. H., 21 × 3″; L. H., 19 × 3″
Bridges, width	1⅜″
Slide valves, kind	Richardson balanced.
" " greatest travel	5½″
" " lap of	Outside, ¾″, inside, 0″
" " lead in full stroke	1/16″
Valve, steam packing, kind	U. S. metallic.
Driving wheels, diameter outside of tire	51″
" journals	8½″ diameter × 9″ long.
Engine truck, style	2-wheel swing bolster.
" " wheels, kind	Krupp steel tired spoke.
" " " diameter	30″
" " journals	6″ diameter × 10″ long.
Crank pin journals, main pin, main rod	6″ " × 6″ "
" " " " " side "	6½″ " × 5½″ "
" " " inter " " "	5½″ " × 4½″ "
" " " front " " "	5″ " × 3¾″ "
" " " back " " "	5″ " × 3¾″ "
Boiler, working pressure in lbs. per sq. in.	180
" style	Wagon top.
" diameter of first ring outside	62″
" thickness of steel	¼″, 5/16″ and 5/16″
" maker " "	Worth.
" horizontal seams	Sextuple riveted, butt joints.
" circumferential seams	Double.
Firebox, length	108⅜″
" width	41⅜″
" depth	Front, 62¾″; back, 59¾″
" thickness of steel	Crown, 5/16″; tube, ½″; Sides, 5/16″; back, 5/16″
" maker " "	Otis.
" water space	Front, 4″; sides, 3″; back, 3″
" crown stayed by	6″ × ¾″, crown bars.
Tubes, material	Charcoal iron.
" No. of	301
" Outside diameter and thickness	2″ O. D. × 11″ W. G.
" length, over tube sheets	12′
Heating surface, tubes in sq. ft.	1,878
" " firebox "	168.2
" " total in "	2046.2
Grate " " "	31.1
" style	Rocking.
Ash pan, style	Sectional.
Exhaust nozzles, style	Single.
" " diameter	5″, 5¼″ and 5¾″
Throttle	Balanced valve, double poppet
Smokestack, inside diameter	14″ near bottom.
" top above rail	14′ 5″ Eng. Central.
Boilers supplied by	2″ 10 monitor injectors.
Tender, weight empty in lbs.	35,000
" Wheels, No. of and diameter	8—33″
" " kind	Rochester cast-iron chilled plate.
" journals	4¼″ diameter × 8″ long.
" total wheel base of	15′ 3½″
" frame, style	6½″ × ⅜″ × 4″ Angle Iron S. L. W. standard
" truck "	4 wheel, Channel iron, center bearing F. and B. addition alside bearings on B truck, S. L. W. standard.
" tank, water capacity	4,000 galls.
" " coal "	8 tons.
Total wheel base of engine and tender	47′ 2⅛″
" length " " " "	57′ 1⅝″

PHILLIPS' FLYING MACHINE.

IN our May issue we described a flying machine which has been perfected by Mr. Lawrence Hargrave, of New South Wales. We now publish four views of a flying machine recently perfected by Mr. Horatio Phillips, of Harrow, of which two show the machine in the act of flying, it being lifted from 2 ft. to 3 ft. off the ground. Our illustrations are, of course, from photographs, and it will be easily understood how difficult it is to photograph a piece of mechanism of this description, moving at so high a speed, when close to it. The aerial propeller itself is not visible, the motion being too quick, the revolutions per minute being about 600. Our illustration, fig. 1, shows the "whirling machine" which Mr. Phillips has used in the course of his numerous experiments in order to ascertain the best form of slat or sustainer, while below it the flying machine is seen at rest.

We have recently seen another aerial machine of Mr. Phillips's in operation, the same engine and boiler, however, being used. In this latter trial the weight of 72 lbs. was lifted clear of the track; but the distance which the machine flew was not so great as on the first trial we witnessed, and this in spite of the fact that the day was more favorable, there being less wind, the travel of the breeze being probably about 10 miles per hour. From this it may be argued that Mr. Phillips has not improved the first machine we saw by the modifications he has introduced. The chief alteration was an addition to the area of sustainer surface, and Mr. Phillips is of opinion that he has gone beyond the limit of the power at his disposal with the present propelling mechanism. The slats or sustainers in the last machine were also placed at a slight angle, while the first were entirely horizontal. This had the effect of reducing the speed and therefore the efficiency of the surfaces. The speed which Mr. Phillips has in view to commence with is 40 miles an hour, and in order to reach this speed lighter propelling machinery will be required. At present Mr. Phillips has turned his attention more especially to the sustainer surfaces. Although the engine is a very nice specimen of mechanical work, much might be done in lightening this part of the apparatus, especially in regard to the boiler.

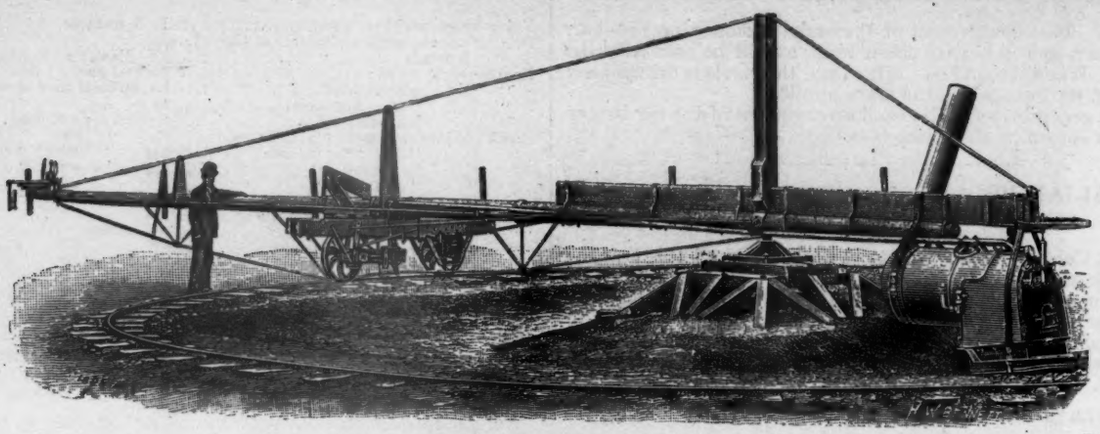


FIG. 1.—EXPERIMENTAL WHIRLING TABLE.

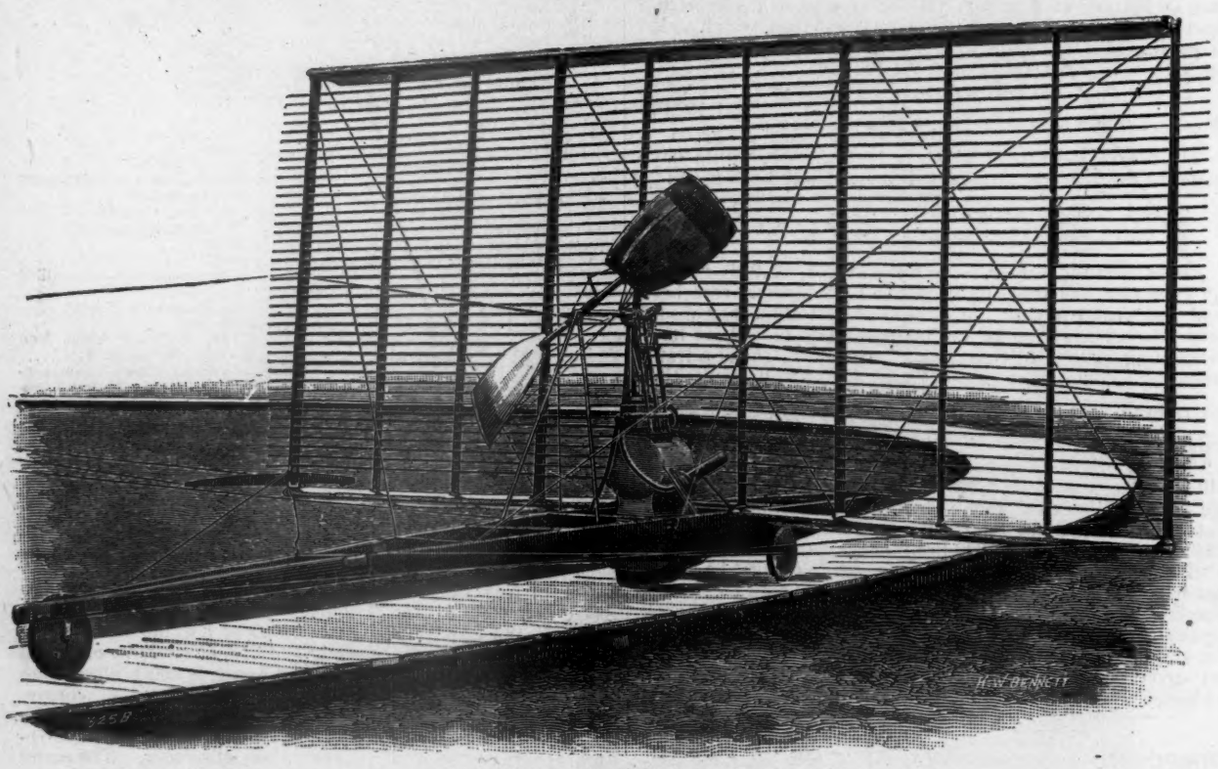


FIG. 2. -FLYING MACHINE AT REST.

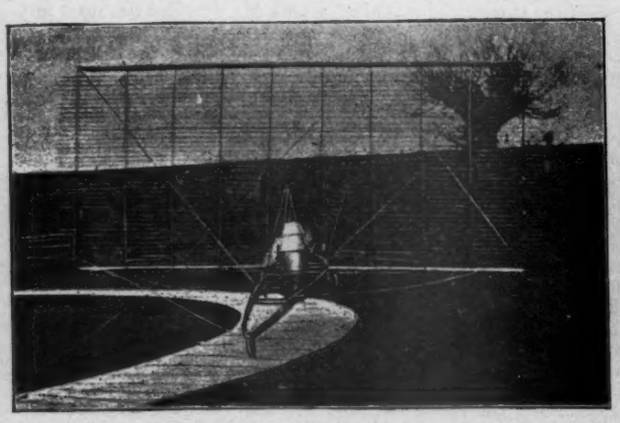


FIG. 3.—MACHINE IN MOTION, FRONT VIEW.

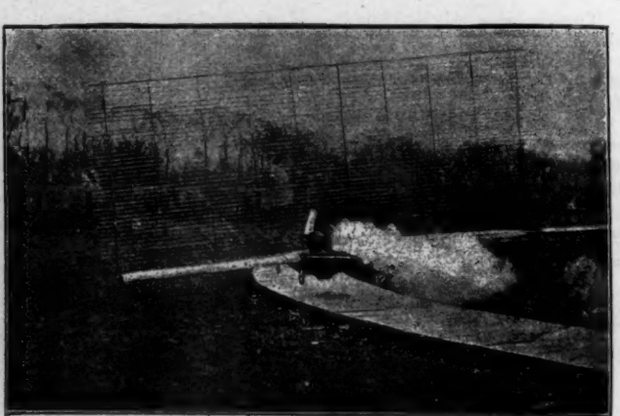


FIG. 4.—MACHINE IN MOTION, REAR VIEW.

Mr. Phillips is now turning his attention to this part of the problem, and hopes soon to show considerably higher results. The interesting point, of course, will be reached when an apparatus large enough to carry an operator has been constructed.

Another detail to which attention has been turned is the leveling of the circular track on which the machine runs; this was known to be somewhat out of truth, but on testing it was found that there was a difference of 4 ft. 6 in. in the level of

the two sides; this has now been put right. Since our notice appeared, a large number of persons interested in these matters have paid a visit to Mr. Phillips' trial ground, and the operations are being watched with great interest by all persons connected with aeronautical matters.

A word should be said about the whirling machine. As will be seen, it consists of a spar pivoted near one end, the balance being obtained by a locomotive boiler of about 10 H. P., which is mounted on a short arm of the spar. The engine which drives the apparatus is on a two-wheeled carriage running on rails. The engine, which is attached to the long arm of the spar, not far from the pivot, runs round on a circular rail, and carries the spar with it, the steam being conveyed from the boiler to the engine by a pipe running on the spar. Beyond the carriage there projects a long arm, the end of which sweeps through a large circle; by this a rapid motion is obtained. The circle is 323 ft. in circumference, and a speed of 70 miles an hour is thus obtained. The slats or sustainer surfaces to be experimented on are, of course, placed at the end of the spar, and connected to an apparatus by which the weight lifted and the power required to tow the surfaces through the air are automatically registered.—*Engineering.*

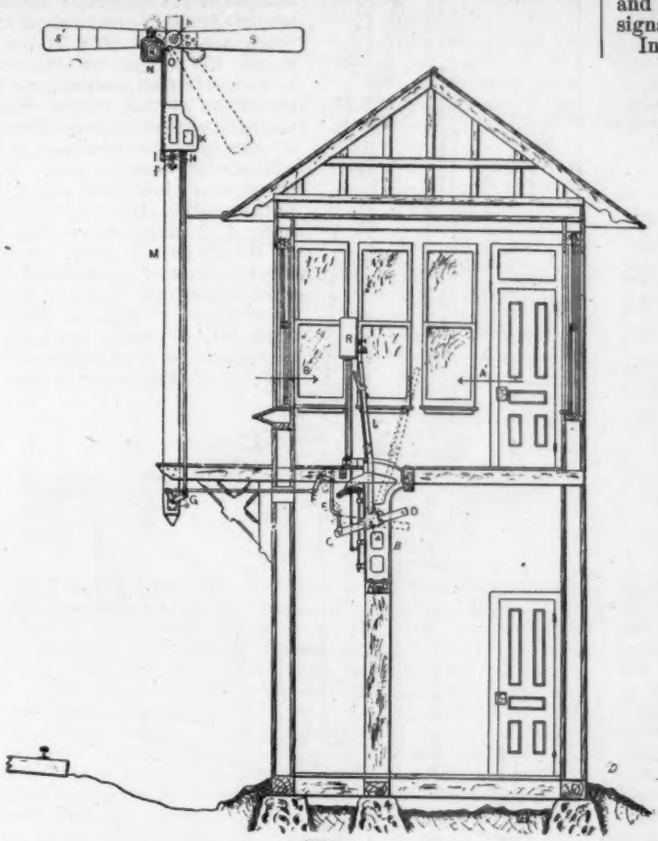


Fig. 5.

PATENALL'S IMPROVED SYKES' SYSTEM OF BLOCK SIGNALS.

BY THE JOHNSON RAILROAD SIGNAL COMPANY, RAHWAY, N. J.

II.

THE article which was published last month gave a general explanation of the principles on which the Sykes system of block signals is worked. In this one a description will be given of some of the special instruments and appliances which the Johnson Railroad Signal Company furnish for operating this system. These appliances embody not only the features which were originally brought out by Sykes, but also the improvements made by Mr. Patenall, an engineer engaged with the Johnson Company.

It should be explained here that the apparatus which was described in our first article was of a mere rudimentary type, and was illustrated merely to elucidate the general principles which are embodied in the Sykes system of block signaling.

In the article referred to it was shown how a road operated by the block system is divided into sections, with a signal station between each of them. It was also stated in that article that the apparatus illustrated therein was not shown in its true position in relation to the tracks, nor in its true proportions; some of the parts being relatively magnified in size for the purpose of representing them clearly. In the engravings which were given the locking-bar *b c* was shown attached to the signal-lever. In the apparatus which is now used this bar is inside of the indicator case, and controls the locking mechanism of the signal-lever by means of connections which will be described hereafter.

Figs, 5, 6, and 7 represent sectional views of a building for containing the signal apparatus of an ordinary station between two sections of a double-track road, and which also serves as a cabin or lodge* for the men who operate the signals.

Fig. 5 is a sectional view drawn on a plane transversely to the tracks. Fig. 6 is drawn longitudinally to the tracks, but looking toward them in the direction of the dart *A'*, of fig. 5, and fig. 7 is also a longitudinal section, but looking at the signal apparatus in the direction of the dart *B'*.

In order to simplify the illustrations and descriptions as much as possible, it has been assumed that there are no turnouts, cross-overs, switches, or other complication of tracks at the station where this lodge is located, but that at the place the signals must control only the movement of trains on the two main tracks.

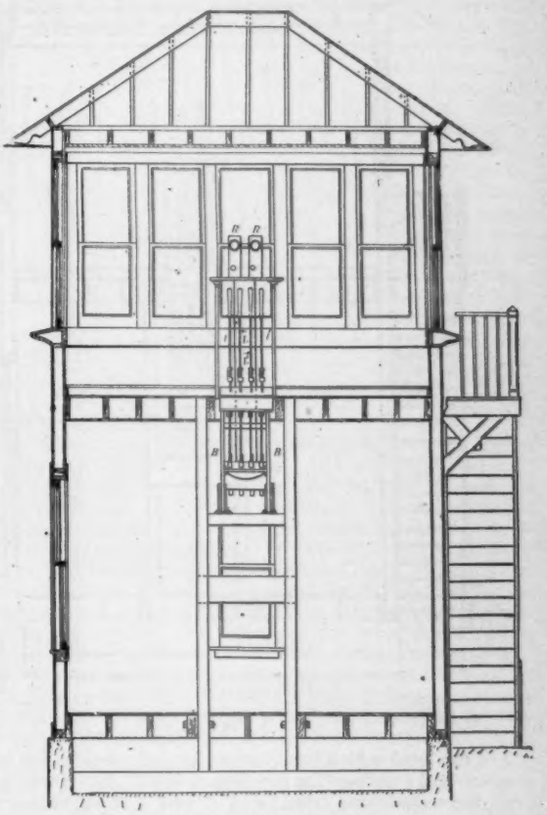


Fig. 6.

As shown by the engravings, structures of this kind are usually two stories in height, so that the signalmen, who occupy the upper story, can have a better view of the tracks from an elevated position than they otherwise could have.

At the station represented by the engravings the home signal post *M* is attached to the building, but this is a matter of convenience merely, as it may be located in any other suitable position. The post in this case supports two semaphores, *S* and *S'*. The one *S*, on the right side of the post, is the one which governs the trainmen in approaching the station, in the direction in which we are supposed to be looking at it in fig. 5. If we were coming in the opposite direction, and from the other side of the station, then the signal *S'* would, of course,

* These structures are sometimes called signal "cabins" and sometimes "towers." Neither of these terms are satisfactory. The word "lodge," which is defined by Webster as "a shelter in which one may rest," seems more appropriate.

appear on the right side of the post. It will thus be seen that the signal on the one side of the post governs the trains running in one direction, on one line of rails, and that on the other side controls the trains running in the reverse direction on the other line, and that these signals always appear on the right side of the post to the persons who must be governed by them. Besides these two signals there are also two distant signals located from 1,200 to 1,600 ft. from the signal station, as explained in the article published last month. These are not shown in figs. 5, 6 and 7, but it will be assumed that they are located in the positions designated. In order that distant signals may be readily identified, the ends of their semaphores are usually made of fish-tail form, as shown in fig. 8. Such signals are most commonly connected by wires or rods with the signal lodge, by means of which they are raised and lowered.

For operating the two home and two distant signals, four levers, *L*, *l*, *L'* and *l'*, fig. 6, are provided in the signal lodge.

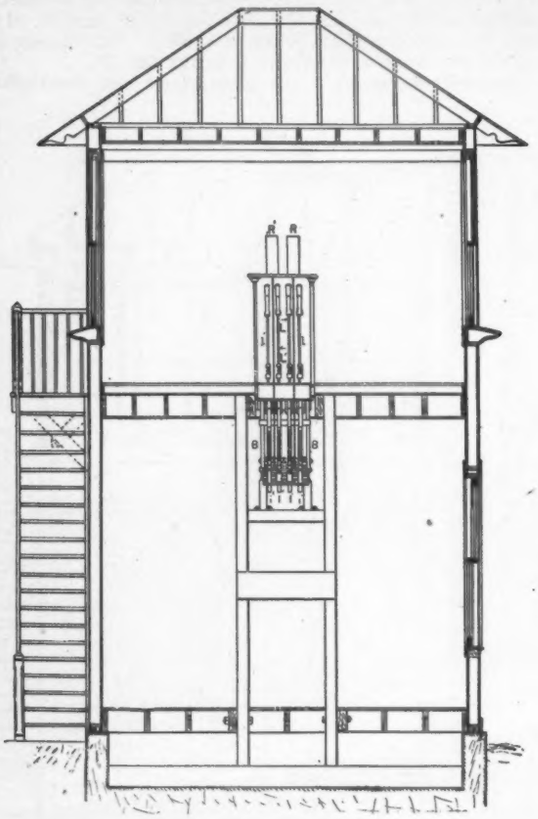


Fig. 7.

L is the lever which is connected to and operates the home signal *S*, and *l* the one for the distant signal, for, it will be assumed, the west-bound track, and *L'* and *l'* being connected with the signals which refer to the east-bound track.

The connection of the lever *L* with the semaphore *S* is clearly shown in fig. 5, *L'* being connected to *S'* in a similar way.

L is fulcrumed at *a*, fig. 6, and is connected to the semaphore *S* by mechanism, which is clearly shown and will be readily understood from the engraving. The position of the lever and that of the signal when it is lowered are shown by dotted lines, from which their operation will be apparent.

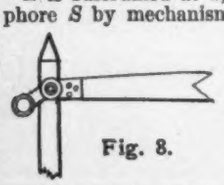


Fig. 8.

N is a lamp, and *O* is what is called a spectacle-frame, which is fastened to the shaft *h*, to which the semaphore *S* is attached. The spectacle-frame carries a red lense, *g*, which comes in front of the lamp when the semaphore *S* is raised into the position in which it is shown by full lines, and in which it indicates "DANGER." At night the red lense coming in front of the lamp shows a red light, which also indicates "DANGER." When the signal is lowered, to indicate "LINE CLEAR," the lense is raised, and the lamp then shows a white light at night.

R, *R'* are indicator cases, to which reference was made in the article published last month. *R* refers to the west-bound and *R'* to the east-bound track.

For the purpose of explaining the purpose of the apparatus employed, it will be assumed that the illustrations represent a signal station at *A*, in figs. 1, 2, 3 and 4, published last month. It will be supposed, further, that a train is approaching station *A* on the west-bound track, and that section 2 beyond *A* is clear. It was explained that "before *A* admits a train on section 2 it should be certain that there is no train on it or that it is 'clear.' If *A* depends upon information received by telegraph from *B*, there is always a chance for mistakes. They may misunderstand each other, or forget, go to sleep, or do many other things to which fallible and indolent human nature is prone. For this reason the mechanism of this system of signals is arranged so that when the signal at a station is raised to indicate 'DANGER' it is locked in that position, and the signalman at that station cannot unlock it without the co-operation or consent of the signalman at the next station ahead of him. That is, when *A's* lever and signal are in the position shown by full lines in fig. 1, *A* cannot move them until *B* unlocks *A's* lever. *B* does this by means of an electrical connection between *A* and *B*, which is operated by what is called a 'plunger,' *P'*, which is a knob or button similar to an ordinary bell-pull, which is arranged in front of

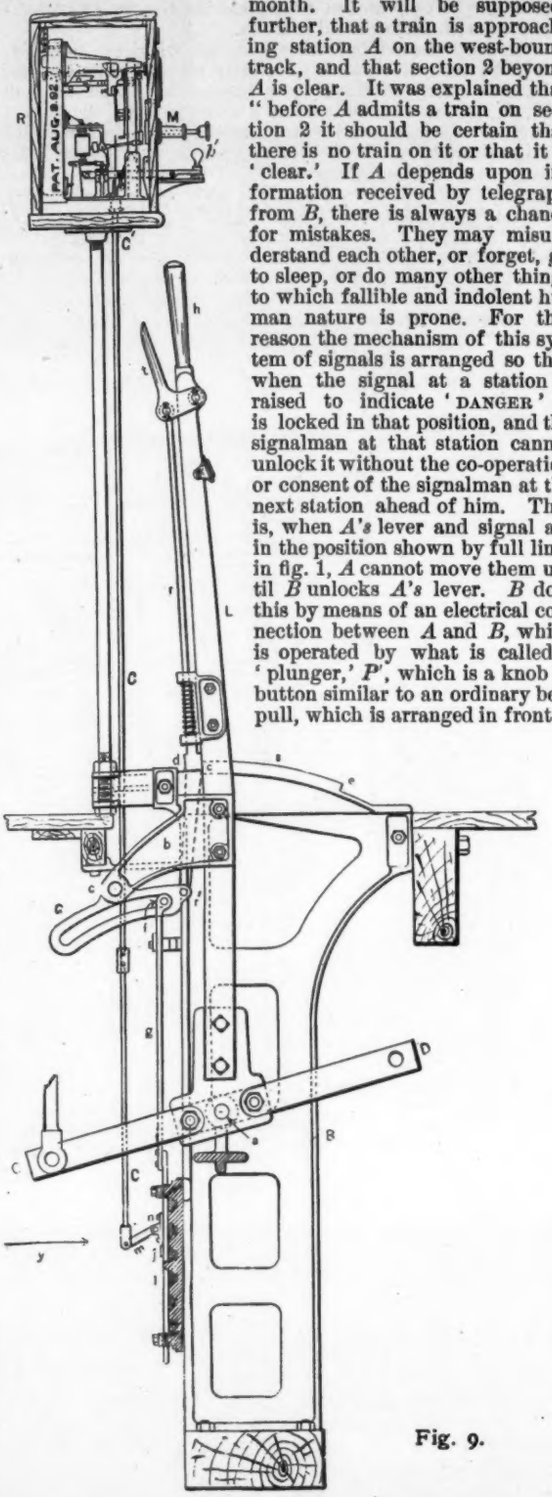


Fig. 9.

his indicator case, *I'*. The construction of this will also be explained hereafter."

We will now proceed to explain the mechanism by which *A's* signals are moved and controlled, and in the next article that by which the signalman at the next station, *B*, is enabled to control the signals at *A* will be described. Fig. 9 is an engraving showing a side view of the lever *L* of fig. 5, on an enlarged scale, so that its different parts may be seen more clearly than they are shown in fig. 5. This and the other levers are connected to an iron frame *B*, as has been explained, by a fulcrum or shaft at *a*.

The horizontal arm *C D* is connected to the signal, either as shown in fig. 5, or in any other convenient way. To the lever *L* a bracket *b*, fig. 9, is bolted, which carries a slotted link, *G*, similar to the links used for operating locomotive valves. This link is pivotally connected to the bracket at *c*. The top of the lever has a hand-latch *t*—also similar to those used on the reverse-levers of locomotives—which is connected by a rod *r* to a detent *d*, and to the link *G'* at *r'*. *s* is a sector which has two notches *c* and *e*, with which the detent *d* engages, and thus holds the lever in either of its two extreme positions. It is clear that before the lever can be thrown back from the position in which it is shown, or toward the right, that the detent *d* must be raised so as to be disengaged from the notch *c* in the sector *s*.

To do this the latch *t* must be pressed against the handle *h* on the end of the lever. As already explained, the latch *t* is connected by the rod *r* to the detent *d*, and also to the link *G'* at *r'*. The slot of the link carries a roller *f*, which is attached to a rod or bar *g*, which in turn is attached to a vertically sliding locking-plate *I*. A similar locking-plate is provided for each one of the levers. This *I*, *I'*, *i* and *i'* are shown in fig. 7. *I* is the locking-plate connected with the home signal lever for the west-bound track. This plate has a lug *j*—see fig. 9—riveted to it. In order to show these and some other parts more clearly, they are represented on an enlarged scale in figs. 10 and 11, fig. 10 being a similar view of these parts to that

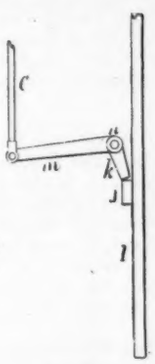


Fig. 10.

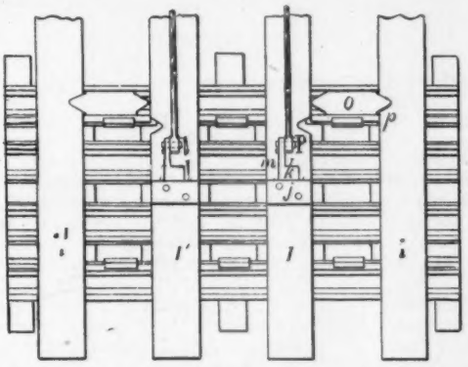


Fig. 11.

shown in fig. 9, and fig. 11 is a view looking at them in the direction of the dart *y*, fig. 9, or as they appear in fig. 7. Attached to the locking-frame *B*—see fig. 9—is a short shaft *n*, which has an arm or dog *k*, shown in figs. 10 and 11, attached to it.* This dog engages with the lug *j*, as shown in fig. 10. It is plain from this engraving that when the dog is engaged with the lug *j* that it will be impossible to raise up the locking-plate *I*, the bar *g*, fig. 9, the rod *r'* of the link, the detent *d*, the rod *r*, or to press the latch *l* against the handle *H*. In other words, under these conditions it will be impossible to unlock the lever by withdrawing the detent *d* from the notch *c* in the sector *s*. Consequently as long as these conditions exist the lever will be securely locked in the position in which it is shown. From figs. 9 and 10 it will be seen that the shaft *n* has an arm *m* attached to it. This arm is connected by a rod *C*, *C*, *C'*, with the indicator case *R*.

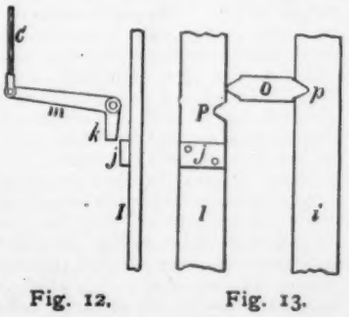


Fig. 12. Fig. 13.

Before proceeding farther and showing how the signalman at station *B*, figs. 1, 2, 3 and 4, can unlock the signal in *A's* lodge, it will be necessary to explain the construction of the appliances in the indicator case *R*, by means of which this is done. The operation of the levers and signals will, however, first be explained, the description of the apparatus by which the signalman at one station controls the signals at the station behind him being reserved for another article.

Last month it was stated that the levers by which the signals are operated are arranged in such a way that *in indicating danger*, the movement of the distant signal always *precedes* that of the home signal. The reason for this is that if there is danger beyond the home signal, the distant signal should indicate it first, so that a train approaching a station may be stopped before it reaches the home signal. If a car or other obstruction or defect in the track was located immediately beyond the home signal, it might not be possible to come to a stop if this were not known until the home signal was visible. In fact, as has already been explained, the object of distant signals is for the purpose of giving engineers warning of obstructions at a sufficient distance from stations to enable them to stop before reaching the next block section which begins at the home signal.

For these reasons the levers by which the home and distant signals are operated are arranged to "interlock" with each other—that is, such mechanical appliances are provided that if the two signals are lowered to indicate LINE CLEAR, the distant signal must always be raised *first* before it is possible to raise the home signal.

If the signals are at "DANGER," then the distant signal cannot be lowered until *after* the home signal has been lowered. The reason for this is that the object of lowering the distant signal is to indicate that the line is clear not only between the distant signal and the home signal, but in the section beyond. It would obviously be a contradiction to lower the distant signal to indicate that the line is clear in the next section so long as the home signal shows that it is not. If the section ahead is clear, this should first be shown by lowering the home signal, and then the lowering of the distant signal will reiterate this indication, and also that the space between the distant and the home signals is also clear.

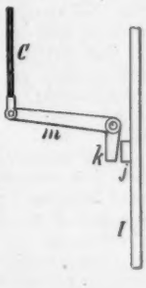


Fig. 14.

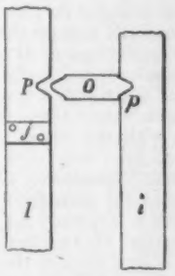


Fig. 15.

The mechanism provided for interlocking the levers is shown in figs. 9, 10 and 11. As before pointed out, figs. 10 and 11 show two views of the locking parts on an enlarged scale. It will be supposed that the signal *S* of fig. 5 is at danger, and the other parts are in the position shown in figs. 9, 10 and 11. If the rod *C* and arm *m* are lowered so that the dog *k* engages with the lug *j*, evidently, as has been explained, the plate *I* cannot be raised, and consequently the latch *d*, fig. 9, could not be lifted out of engagement with the notch *c*, and therefore the lever could not be moved. It will be noticed that the *latch* of this lever is locked and not the lever itself. In some of the earlier forms of signal apparatus the levers themselves were locked, and it was then found that the parts became worn, and that consequently the locking appliances did not always hold the levers fast, as they were intended to do. In the arrangement which is here illustrated, and which is now generally employed in the best interlocking apparatus, the signalman is not able even to commence to make any movement of signals until *after* the locking or unlocking of the levers has been completed. The rod *C C C'*, fig. 9, may under certain conditions be raised up by the signalman pulling out the handle *b'*, fig. 9, in the indicator *R*. The movement of this handle is, however, controlled by the signalman at the next station ahead by means of an electrical connection between the two stations, which will be explained later. For the present it will be supposed that the rod *C*, dog *k*, and plate *I* are in the positions shown in figs. 10 and 11; *i*, fig. 11, is the locking-plate connected with the distant signal of the west-bound track. On the locking-frame, a sliding piece *O* is fitted between the two plates *I* and *i*, so that it can slide horizontally. Its ends are pointed so that they can fit into corresponding notches *P* and *p* in the locking-plates, when these

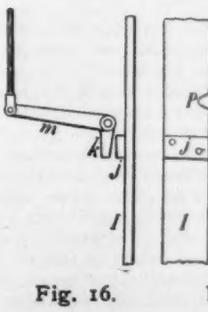


Fig. 16. Fig. 17.

* For the sake of clearness the bearings of this shaft are omitted in figs. 10 and 11, but are shown in fig. 9.

notches come opposite to the sliding piece. When *I* and *i* are in the position shown in fig. 11, the slide *O* engages with the notch *p* in *i*. It is obvious that under these conditions *i* cannot be raised or lowered. As *i* is connected with the latch of the distant lever *l*, it is plain that with the parts in the position in which they are represented, that the signal lever will be locked. If, now, the knob *b'*, fig. 9, was unlocked, so that the signalman at this station can pull out the knob, and he should do this, it would raise up the rod *C' C* and the arm *m* into the position shown in fig. 12, in which the dog *k* will be disengaged from the lug *j*. In fig. 13 the plates *I* and *i* are shown in the same positions in which they are shown in fig. 11—but from fig. 12 it is plain that the plate *I* may now be raised up, and if it is that it will release the latch of the signal lever, and the latter may then be thrown over. When the latch falls into the notch *e*, fig. 9, it will depress the end *r'* of the link *G* and raise its opposite end, which will lift the plate *I* into the position in which it is shown in figs. 14 and 15. It will be understood that this movement of the signal lever has lowered the home signal to indicate "LINE CLEAR," and that the fall of the latch has brought the plate *I* into the position shown in the figures last referred to—that is, the movement of the lever has been completed, and it has been relocked in its new position, and it is the movement of the latch in relocking which has brought the plate *I* into the position shown in figs. 14 and 15. From fig. 15 it will now be seen that the slide *O* is then free to move toward the left side. If an upward strain is brought on the bar *i*, its action on the lower inclined side of the end *p* of the piece *O*, it will tend to push *O* toward the left side and into the notch *P*. As *i* is connected with the latch of the signal lever, any force exerted on this latch would force the slide *O* out of engagement with the notch *p*, and thus release the plate *i* and the latch of the lever with which it is connected. The home signal may, therefore, then be lowered, and when the latch of its lever falls into the notch it would occupy when the signal is lowered, the plate *i* would be in the position shown in fig. 17, and the sliding piece *O* will be forced into the notch *P* in *I*, so that the home signal lever will then be locked—that is, both signals will be lowered to indicate LINE CLEAR, and the home signal lever will be locked in that position. It cannot be unlocked without throwing over the distant signal lever, lowering that signal and locking its lever, which will again bring its locking-plate *i* into the position shown in fig. 15. This will allow the sliding piece *O* to move toward the right when a force is exerted on *I*, which will unlock it.

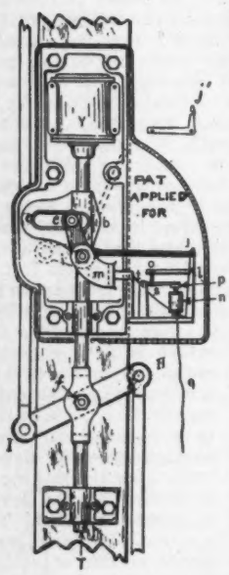


Fig. 18.

It will thus be seen that in lowering the signals to indicate "LINE CLEAR" the home signal must always be moved first, and that in restoring them to danger the distant signal must be moved first. The signals for the east-bound track are controlled in the same way by means of the locking-bars *I'* and *i'*, fig. 11.

From what has been said, it will be seen that when the signals at a station are lowered to indicate "DANGER"—which is their normal position— the operator at that station cannot lower them until the signalman at the station ahead of him has released the locking-bar connected with the home signal lever. The home signal can then be lowered and afterward the distant signal. When a train has passed, or for any other reason it is desirable to raise the signals to indicate "DANGER," the distant signal must be raised first and then the home signal.

It might happen, however, that a signalman through neglect, forgetfulness, or other cause might fail to restore his signal to danger after a train has passed. To guard against this, and to insure that the home signal will always be raised after a train has passed a signal station, what is called an electric slot instrument is provided. This is shown attached to the signal post at *K* in fig. 5, and is represented in a larger scale in fig. 18, with the cover of its case removed, so as to show its working parts. From fig. 5 it will be seen that the horizontal arm *C D* of the signal lever is connected to the semaphore *S* by means of a rod *E*, a bell-crank *F*, a rod *F G*, another bell-crank *G*, a rod *G H*, a lever *H I* and a rod *I O*. The lever *H I* is fulcrumed at *f*, as shown in figs. 5 and 18. The fulcrum *f* is attached to a vertically sliding rod or bar, *Y T*, which has a slotted casting *c b* attached to it. *c i j* is a bell-crank having a fixed fulcrum at *i* and a pin *c*, which can move horizontally in the slot *c b*. *n* is an electro-magnet connected with a battery in any convenient location by a wire *q*, and also with a "track circuit," which will be explained later. *p* is an armature attached to a lever *t p* fulcrumed at *t*. *o l j* is a bell-crank attached to a fixed fulcrum at *l*. The upper end *j* has a hooked end shown above at *j'*, where the bell-crank is shown detached from the other parts. This hooked end can engage with a pin on the end *j* of the arm *i j* of the larger bell-crank. The end *o* of the smaller bell-crank is connected to the lever *t p* by a short link, *o s*. It will be evident now that if the hooked end of the smaller bell-crank is engaged at *j* with the arm *i j*, of the larger one, that so long as the armature *p* is attracted by the electro-magnet *n*, that the smaller bell-crank *o l j* will be held in engagement of its hooked end with the arm *i j* of the larger one, and will hold the latter in the position in which it is shown so long as a current of electricity is passing through *n*. If the current is broken, then the armature will be released and the small bell-crank will be disengaged at *j* and release the arm *i j* of the larger one, and if any downward strain is exerted on its arm, *c i*, it will assume the position shown by dotted lines. This will allow the rod *Y T* to fall and the fulcrum *f* of the lever *I H* will fall with it. As the semaphore is counterweighted so as always to assume a "DANGER" position unless it is constrained to rise, the release of the fulcrum *f* will permit the spectacle-frame *g h*, fig. 5, to fall, which will raise the semaphore to indicate "DANGER."

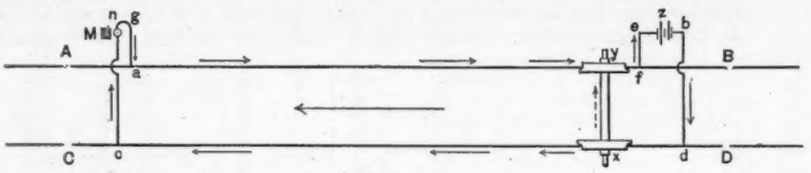


Fig. 19.

It remains to explain the action of the "track circuit," as it is called. When this means is employed for operating signals, or as a safeguard in case the signalman fails to operate them, the rails of a short section of the track are insulated—that is, some non-conducting material is placed between the ends of the rails and between them and the fish-plates, by which the rails are connected together. Thus, in fig. 19, suppose that *A B* and *C D* represent the two rails of a track, and that these are insulated from the adjoining rails at *A*, *B*, *C* and *D*. Suppose, further, that *M* is a signal post, *n* an electro-magnet, like that shown in fig. 18, and *z* a battery. If one pole of the battery is connected by a wire, *b d*, to the rail *D C*, and *D C* is connected to the electro-magnet *n* by a wire, *c n*, and the electro-magnet is connected by a wire *g a* to the rail *A B*, and *A B* by a wire *f e* with the battery *z*, then the current of electricity would flow from the battery in the direction *z b d c n g a f e*, as indicated by the small darts. The effect of this would be to energize the magnet *n*, which would attract the armature *p*, fig. 18, which would thus hold the small bell-crank *o l j* in engagement with the arm *i j* of the large bell-crank, as has been explained, and the signal would then remain in its lowered position, if the operator should throw over his lever. Electricity, however, will always take the shortest circuit possible, and therefore if a pair of wheels, *x y*, of an engine or car should be rolled on to the insulated section *A B C D*, fig. 19, so as to place the rails *A B* and *C D* in electrical communication with each other, then the current would flow in the shorter path, *z b d x y f e z*, and would not pass through the electro-magnet *n*, fig. 18. It would, therefore, be dead and would no longer attract its armature *p*, which would disengage the bell-crank *o l j*, which would release the arm *i j*, and this would permit the large bell-crank to turn on its pivot *i* and the rod *Y T* to fall. This would lower the fulcrum *f*, which would raise the signal, as has been explained.

Y is a cylinder with a piston in it attached to the rod *Y T*, and intended only to provide an air-cushion to resist the too sudden fall of *Y T* and the consequent shock to the parts connected with it.

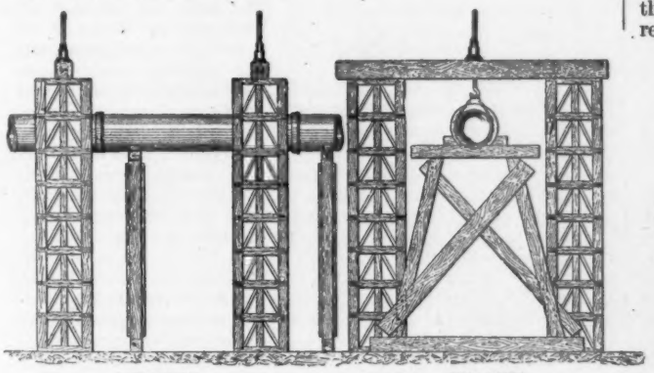
From this explanation it will be seen that, if the signalman should fail to lower his signal, after a train had passed his station, that whenever a vehicle ran on the insulated section of the track adjoining his signal, the latter would be raised automatically by the action of the wheels, and it would then be impossible to lower it so long as the insulated track is occupied.

(TO BE CONTINUED.)

AN EXPERIENCE WITH A 24-IN. GAS MAIN.

At the March meeting of the Technical Society of the Pacific Coast Mr. J. B. Crockett read a paper on An Experience with a 24-in. Gas Main, which involved not only the raising of the main, but also that of holding it with the earth subsiding all about it. The pipe was laid beneath the surface of the marsh on Santa Clara Avenue, San Francisco, Cal., for a distance of 1,424 ft. It was necessary to raise the main without cutting it or breaking it, and its success depended in a great measure on its flexibility, due to lead joints. Had the joints been of cement, as they are almost uniformly made in Eastern cities, the rigidity of the pipes and joints would, without doubt, have caused a break, or perhaps many serious breaks; but with about 100 lead joints 4½ in. deep and ¼ in. thick it became possible to raise the main without a fracture.

The first section to be raised weighed about 260,000 lbs., and the method employed in raising it was as follows: The pipe was first uncovered, the trench extending to the bottom of the main, and at intervals at 12 ft. of its entire length house mover's frames were placed on each side, one above another, to the desired height. A 12-in. × 12-in. timber was placed across these tiers of frames, passing over the pipe just behind each joint. Heavy chains were passed around the pipe, back of each heel, and what is known as a 2-in. "holder screw" was hooked to each chain and passed through a hole in the timber above. On the upper surface of the timber was an iron washer, and on this rested the large nut on the thread of the holder screw.



SIDE VIEW. END VIEW.

FIRST MANNER OF LIFTING AND SUPPORTING PIPE.

After taking up the slack on each chain, a man was detailed with a wrench to each screw, and at a signal from the foreman each man took one turn of the wrench, and the pipe was gradually raised. As the main was raised from the marsh, a gang of men was employed in blocking under it, to prevent its falling in case of the accidental breaking of any part of the lifting machinery, until finally, when it was raised to the desired height, or about 3 ft. below the official grade of the street, the pipe was temporarily supported by house frames. Seven hundred and eighty of these frames, each 2½ ft. high, were used in raising and supporting the pipe.

The next step was the permanent support of the pipe previous to the filling of the street. This was done by constructing a series of wooden trestles, 5 ft. wide at the top and 12 ft. wide at the bottom. They were made of 8-in. × 8-in. uprights with a sill underneath, and a cap at the top of the same dimensions, and braced diagonally by pieces 2 in. × 10 in. on each side. After the completion of the trestles, all the other supports, including the house frames used for raising, were removed, and apparently nothing remained to be done but to fill in the street with solid filling. The pipe had been raised without accident of any kind, all the joints had been recaulked where they had drawn, and the permanent supports were amply strong.

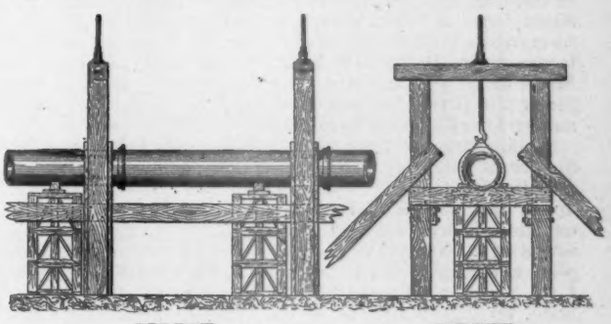
The filling of the street was commenced immediately after the pipe was raised.

As fast as the street was filled to grade, a gang of men kept the 24-in. pipe uncovered, and all went well until the fill reached the corner of Santa Clara Avenue and Arkansas Street, when, on Saturday, April 11, 1891, at 11 o'clock P.M., the northerly side of the street began to slide toward the north, carrying the pipe and its supports with it. The main settled 4 ft. and slid to the north 3 ft., and the wooden trestles were canted over in the direction of the slide.

A gang of men was immediately put to work shovelling the rock and earth away from the trestles to remove the pressure against them, and to distribute the material under the pipe. The following day a number of teams were employed to cart the material from the face of the dump, and to spread it along the line of the pipe, under and on each side of it. The object in thus carting the rock was to distribute evenly the load on the marsh, and gradually raise the whole street to the level of the pipe, instead of keeping up to the street grade, and presenting a steep face at the dump. Carting rock was continued until we had filled in solid under the pipe and had built a cartway about 9 ft. wide on each side of the pipe, level with the bottom of it. This required the handling of 5,000 loads of stone. As the stone was hauled ahead and loaded on the marsh, the street continued to settle, carrying the pipe with it

Four days after this first trouble the crossing of Arkansas Street commenced to settle very rapidly, and in 15 minutes the street had gone down 4 ft. The large body of rock settling in the mud raised the surface of the marsh at a point about 100 ft. north of the street, about 5 ft. high, and opened a crevice a foot wide. This was a natural consequence of the displacement of mud by the heavy fill of stone, but why over half of the filled street should slide bodily toward the north, at the same time, and where and when it would bring up were perplexing questions. To ascertain the exact nature of the underlying strata of the marsh, and solve at least one of these problems, we caused soundings to be made in lines 96 ft. long, extending from south to north, at right angles to the pipe, by driving a ¼-in. iron bar into the ground. The crust of the marsh was found to be fairly firm to a depth of 3 ft., consisting of a sort of marl.

At the northerly side of the street, after passing through the crust, the bar sank into 19 ft. of soft mud, and then reached hard bottom. At the middle of the street the bar



SIDE VIEW. END VIEW.

SECOND MANNER OF LIFTING AND SUPPORTING PIPE.

went down through 7 ft. of the same mud, while on the south side there were but 2 ft. and 6 in. of the mud under the crust of the marsh. The stratum underlying this mud was an extremely hard clay.

These soundings explained to my satisfaction the cause of the body of rock sliding toward the north. The surface of the marsh was nearly level, but the thick body of soft alluvial mud was resting on a subterranean side hill of hard clay, sloping toward the north with a trend of 14°, and as the rock fill sank into the mud it slid, mud and all, down the slope of the hard bottom.

The soundings also explained the sudden and spasmodic settling of the fill. The 3 ft. of firm crust over the marsh offered a resistance to the load of rock piled upon it, until the load was sufficient to overcome the resistance, when the crust broke, letting the entire fill settle from 4 ft. to 5 ft. at a time.

After the second settling of the pipe it was necessary to resort again to the house frames for raising it, as the wooden trestles had sunk into the marsh and were almost useless. After raising the pipe with screws to the proper height, jackscrews were used for forcing it laterally toward the south, back into its proper line. By continuous wedging under the pipe, using in all about 10 cart loads of wooden wedges, we arranged to keep the pipe in its place until May 1, when another settlement occurred, opening long fissures in the fill, and raising the surface of the marsh to the north about 9 ft., and at the same time opening several long cracks nearly 2 ft. wide. This was the most trying period of the whole undertaking, and as a safeguard I laid a line of 20-in. pipe on the surface of the marsh, south of Santa Clara Avenue, and cut the 24-in. pipe between Missouri and Arkansas streets and at Carolina Street, and put in *T*'s 24 × 20.

This was done so that in the event of the destruction of the 24-in. main, we could, by making short connections with the 20-in. main, provide a way to deliver gas to the city temporarily. Fortunately, however, this new line was never used, but its presence was a source of relief.

The last serious settlement occurred on May 15, 1891, when 12-in. × 12-in. timbers, 30 ft. long, were placed under each length of pipe, back of the joints, and the end of the timber toward the north was blocked up about 2 ft. higher than the south end. With this precaution we were enabled to keep the pipe wedged up in place, although it was a constant source of worry and annoyance, until the rock fill had found a bottom on the hard clay and the street was brought to grade. At the crossing of Arkansas Street, which was the worst part of the marsh, the main was raised at the beginning 16 ft., and the sum of all the settlement at that point was 14 ft.—that is, the entire fill settled into the marsh a distance of 14 ft., so that it was necessary to raise the pipe in all 30 ft., to maintain it at the 16-ft. level.

The contractor continued filling in until July 31, 1891, and the average amount of material dumped each day, from May 1 to July 31, was 23 train loads of nine cars each, or about 207 cub. yds. per day. As the contractor completed filling the street to grade, the pipe was kept uncovered, and a 12-in. × 12-in. timber was placed across each length of pipe, resting on blocking and wedges, chains were passed around the pipe and holder screws were used for sustaining it. For months it was necessary to keep careful watch of the pipe, and men patrolled its entire length day and night, driving wedges and taking up the slack on the chains, wherever needed. In fact, during all this time Santa Clara Avenue became one of the Company's telephone stations, and for a while was the one most frequently used

Finally, in November, 1891, the street had stopped settling, the timbers and screws were removed, and after carefully tamping the earth under the pipe, the trench was filled. Early in October, 1891, notice was received of the intention to grade Santa Clara Avenue west from Carolina Street, and as the 24-in. main extended west as far as De Haro Street (304 ft.), it was necessary to raise it out of the marsh. At De Haro Street the pipe turns at a right angle, and extends to Center Street (510 ft.), and it was necessary to raise the entire 814 ft. an average of about 8 ft. in height.

A pile structure was built to raise and sustain the pipe. Sixteen-in. piles, 50 ft. long, were driven through the marsh into the hard clay bottom. These piles were spaced 12 ft. apart, and were 5 ft. from the pipe on each side. Ten ft. outside of each standard pile a brace pile was driven and sawed off 2 ft. from the ground. On each side of the standard piles, extending down to the brace piles, were diagonal braces 4 in. × 12 in. Caps 12 in. × 12 in. were placed over the main, resting on the top of the standard piles, and a screw passed through a hole in the middle of each cap. The pipe was raised as before described.

When the pipe reached the proper grade, waling pieces 4 in. × 12 in. were bolted on the inside face of the standard piles, and across these were placed two planks 4 in. × 12 in., on edge, resting on the waling pieces and bolted through the piles. The pipe rested on these 4 in. × 12 in. cross pieces, and was prevented from rolling by pieces of 4 in. × 4 in. The entire wooden structure was securely bolted together.

The standard piles were for raising and permanently supporting the pipe, and the brace piles and the diagonal braces were to withstand any side thrust caused by sliding of the marsh.

One of the difficult features of this piece of work was the bracing of the right angle in the main, at the corner of Santa Clara Avenue and De Haro Street. This was accomplished by driving 10 piles around the **T** at the corner, and by a system of diagonal braces. To prevent the pipe from drawing apart, iron bands were bolted around it at the corner, and these bands were connected on each side by rods with turnbuckles.

After the pipe was raised and supported the 12 in. × 12 in. caps were removed and the tops of the standard piles were sawed off below the grade of the street. As the street was filled, the pile structure stood the strain of the street settling, but there was little or no lateral thrust, as the clay under the marsh was nearly level at this point, and the fill did not slide.

MANGANESE STEEL.*

[By Henry M. Howe.

(*Concluded from page 239.*)

Speaking roughly, we may say that water toughening increases the ductility of manganese steel some fivefold, and occasionally even tenfold; while often at the same time doubling the tensile strength.

* A lecture delivered before the Franklin Institute, February 20, 1892.

In fig. 9, I attempt to show simultaneously how the strength and ductility of manganese steel both increase as we hasten the cooling of the metal; in other words, that the faster we cool it, the stronger and more ductile we find it. Each of the several lines here drawn gives the tensile strength (as abscissa), and the elongation (as ordinate) of pieces of manganese steel cooled at different rates, but in all other respects alike. The semi-circles with the letter *N* by them, as before, represent the metal in its natural or slowly cooled state; the black circles show the same properties in the suddenly cooled material, the letter *A* indicating that the metal has been cooled suddenly by a blast of air; the letter *O* that it has been cooled by plunging in oil; and the letter *W* that it has been cooled by quenching in water. Let us confine our attention to manganese steel containing from 9 per cent. to 15 per cent. of manganese.

As before, we see that the increase of elongation is much greater than that of tensile strength; in short, the sudden cooling is more markedly a toughening than a strengthening. Next, we note that, in general, the more sudden the cooling, the greater the strength and the elongation. Air cooling, the least rapid, gives the spots next above those of the natural state; oil cooling, next in order of rapidity, gives the next higher spots, while water cooling, the most rapid of all, gives in general the highest spots of all.

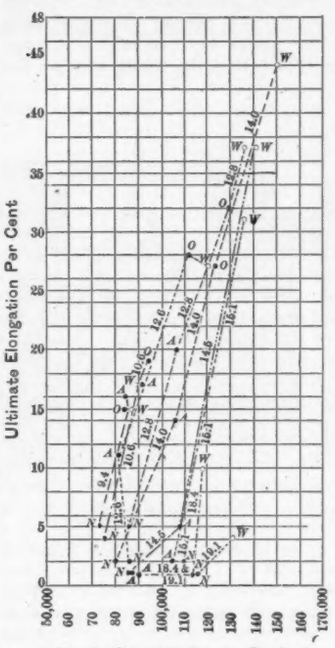


Fig. 9.

TENSILE PROPERTIES OF MANGANESE STEEL.

W = Water-toughened Manganese Steel.
O = Oil " " "
A = Air " " "
N. = Natural State.

Figures give percentage of manganese.

Next, what is truly remarkable, that in many cases these lines are nearly straight and parallel from end to end, showing that the ratio of increase of strength to increase of ductility is nearly constant for varying accelerations of the rate of cooling, and that this ratio is the same, roughly speaking, for manganese steel of different compositions. This certainly seems to indicate that the increase of strength and of ductility are, in the main, due to one and the same ulterior cause. It may be that sudden cooling prevents some change which occurs during undisturbed slow cooling, some change which requires a considerable length of time, and which weakens the metal and lessens its ductility: that at a high temperature the metal assumes a condition which, if preserved by sudden cooling, assures strength and ductility to the cooled metal; while if we cool it slowly, some slow change, decomposition, recomposition or rearrangement occurs, yielding a relatively weak and brittle substance.

But this explanation may be very far wrong, and, if it be right, we certainly do not know what the nature of the supposed change is. A change in the chemical condition of the carbon has been traced to sudden cooling; but this change does not readily explain matters. Sudden cooling changes most of the carbon of carbon steel from the "non hardening" to the "hardening" state; and the hardness and brittleness of suddenly cooled carbon steel are usually attributed to the presence of this hardening carbon. In slowly cooled manganese steel the carbon exists in both the hardening and the non-hardening state; sudden cooling increases the proportion of hardening carbon, a change which would be expected to make the metal more brittle, instead of very much more ductile as it actually becomes.

I have thus far spoken of the effect of the rate of cooling on the ductility and strength of manganese steel. But the temperature from which sudden cooling occurs also affects these properties; and in general we may say that the higher the temperature, provided it does not rise above moderate whiteness, from which the metal is suddenly cooled, the stronger and more ductile will it be. In short, violence of cooling, both as

regards the rate of cooling and the range of temperature passed through, strengthen the material and increase its ductility.

But here a caution. Pieces of a very ductile material may themselves be locally brittle, locally incapable of enduring much distortion without rupture; pieces of a strong material may themselves be relatively weak. Notch a piece of cloth, and you may easily rip it across, though, if unnotched and twisted up into a rope, it would hold five tons. Nick a bar of steel, and a light blow will break it; file away the sides of the nick, and round and smooth the surface there, and you will find the remaining metal still strong. Thus, a crack causes the material to yield to trifling stress, by concentrating that stress into a limited region.

Now, we all know how easy it is to crack common steel when we harden it by plunging it into water while red-hot. And we know that these cracks are caused by the difference between the rates at which outside and inside cool.

The outside cools rapidly, and hence tends to contract rapidly; the inside cools much less rapidly; hence it contracts less rapidly, and thus opposes the effort of the outside to contract, and to reach the dimensions which it would naturally have at the existing temperature. The resistance of the inside thus, in effect, violently stretches the outside, and may stretch it so far as to crack it.

We all know that pieces whose shape causes great and sudden differences between the rate of cooling and contraction of different parts, and especially of adjoining parts—that is to say, pieces of suddenly and greatly varying thickness, are especially liable to crack in quenching.

Much the same holds true of manganese steel, though in an incomparatively smaller degree. While the metal is so ductile as to endure without cracking the distortion due to rapid cooling, yet extremely violent cooling, though it may give to the material itself its greatest strength and ductility, may yet, in case of castings whose shape or size favors cracking to an unusual degree, cause slight surface cracks, which, if they be not removed, may in themselves locally lessen the strength and ductility. Hence, the piece which has thus been very violently quenched may be likened to a piece of copper which has been nicked; the material is extremely ductile, but there is a local defect, which locally impairs ductility, and so weakens the piece as a whole, just as a weak link weakens the chain as a whole.

Hence it may be best, especially in treating thick pieces of cast manganese steel of irregular section and greatly varying thickness, to cool at a moderate rate, as, for instance, by exposing to a blast of cold air, or by repeatedly dipping into water and drawing out again into the air. Naturally, this is especially true of unforged castings whose ductility, and hence whose power of resisting the temporary distortion arising during violent cooling, cannot be expected to equal that of forged pieces. Indeed, I have never known even the most violent cooling to injure forged pieces thus.

Forging.—In heating ingots of manganese steel of usual composition prior to forging them, their temperature must be raised very gradually. The metal conducts heat so slowly that, if exposed when cold to a high temperature, the outside becomes extremely hot, and hence expands greatly, while the interior remains almost cold. The fast expanding outside thus stretches the slowly expanding interior, and may stretch it so much as to crack it. Obviously, it is far better never to allow the ingot to cool, but to place it while still hot with the initial heat of casting, in a hot furnace, and simply leave it there till its interior is well solidified.

Once the material has been forged, however, it may be reheated much more suddenly, without danger of cracking.

For forging, the metal is brought to a light-red heat, and at first *saddened*—that is, made compact with light blows; thenceforth it may be struck heavily. But the hardness which it shows when cold persists even at bright redness, and more work—that is to say, more and heavier blows—are needed in forging it than most steel requires. For those familiar with working very hard steel, the whole may be summed up by saying that manganese steel behaves in forging like carbon steel containing about 1.25 per cent. or even 1.50 per cent. of carbon.

Manganese steel may be rolled hot into sheets as thin as No. 18 gauge, 0.049 in., without special difficulty; and it has been rolled hot to No. 28 gauge, 0.014 in., but with difficulty, for very frequent annealing is needed. It has been rolled cold into much thinner sheets, but it hardens quickly in cold rolling, and must be annealed often.

It has been drawn into wire, 0.0105 in. thick, or of No. 31 B. W. G., No. 30 American wire gauge.

Machining.—Manganese steel of usual composition, while unalterably hard, is yet not so intensely hard that we cannot cut it. For cutting it in lathe or planer, the hardest of carbon or chrome tool steel should be used, and the cutting tools should be made as hard as fire and water will make them. Tools made of Mushet's and other self-hardening steel do not cut it readily, as they lose their edge by "slipping." Of course, the cuts must be very light, and the feed very slow. Exact comparative data are not at hand; but such information as I have indicates that it takes about four times as long to machine manganese steel as common carbon steel. This of course does not mean that it costs four times as much.

In general, it is important to bring the metal while hot as closely as possible to the desired shape, so that but little machining may be needed. It may be shaped by drop forging, hydraulic forging and other special means. It may often be cut advantageously when hot by means of a circular saw, as, for instance, in removing sinking heads.

In some cases cold rolling and other forms of cold working may be applied to manganese steel, in lieu of machining. For, while it certainly does not work as easily when cold as common soft steel, yet its disadvantage in this respect seems much less than in cutting by means of common steel tools.

In many cases, too, it may be punched or pressed cold to shape. When only a little of the metal is to be removed, manganese steel may be ground advantageously with an emery wheel. No special precautions are needed, beyond running the wheel rather slowly, as in grinding hardened steel. It

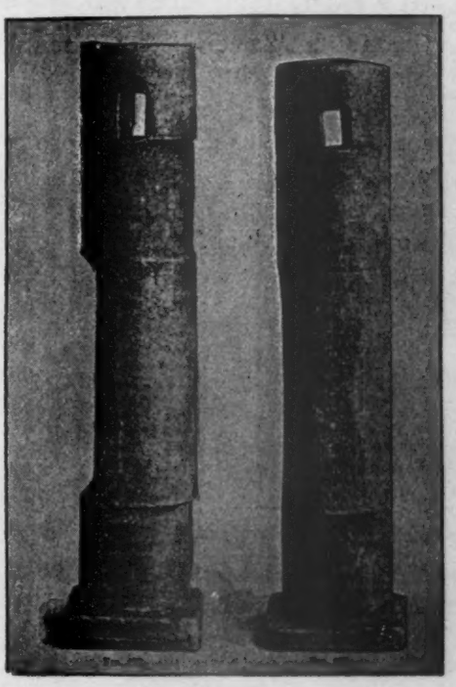


Fig. 10.

costs more to grind manganese steel than to grind carbon steel when unhardened, but decidedly less than to grind hardened carbon steel.

Uses.—Let us next consider the actual and prospective uses of manganese steel.

Its most important single use is for the pins which hold the links of dredgers of the elevator or bucket class, some 4,000 of these pins having been made in the last two months of which I have advices. For these pins a strong and at least moderately tough material is needed, and at the same time one that resists abrasion well, as the sand and grit between the pin and the link in which turns cut sharply. Fig. 10 shows how much better manganese steel resists abrasion under these conditions than the carbon steel with which it competed. The manganese-steel pin, that which is least worn, has endured more than thrice as much as its neighbor.

In other cases of which I have late reports, equally remarkable results have been reached. At Preston, Eng., a full set of manganese-steel pins, after working for eighteen months in sand and gravel, had worn away only about one-eighth as fast as common steel pins. Manganese-steel dredger pins at Hull, Eng., are reported as wearing about one-sixth as fast as those of common steel.

Manganese-steel plowshares are reported as wearing six or seven times as long as chilled cast-iron shares. This is rather surprising, considering that the chilled cast iron is certainly harder than manganese steel.

The side plates of the Blake crusher, those between which

the jaws play, when made of manganese steel, have shown great resistance to abrasion. These particular plates are seven-eighths of an inch thick. When made of hard carbon steel, they were worn out in two months; in crushing granite, when made of manganese steel, they were worn away only one-fourth of an inch in ten and one-half months. In other classes of crushing machinery it has given excellent results.

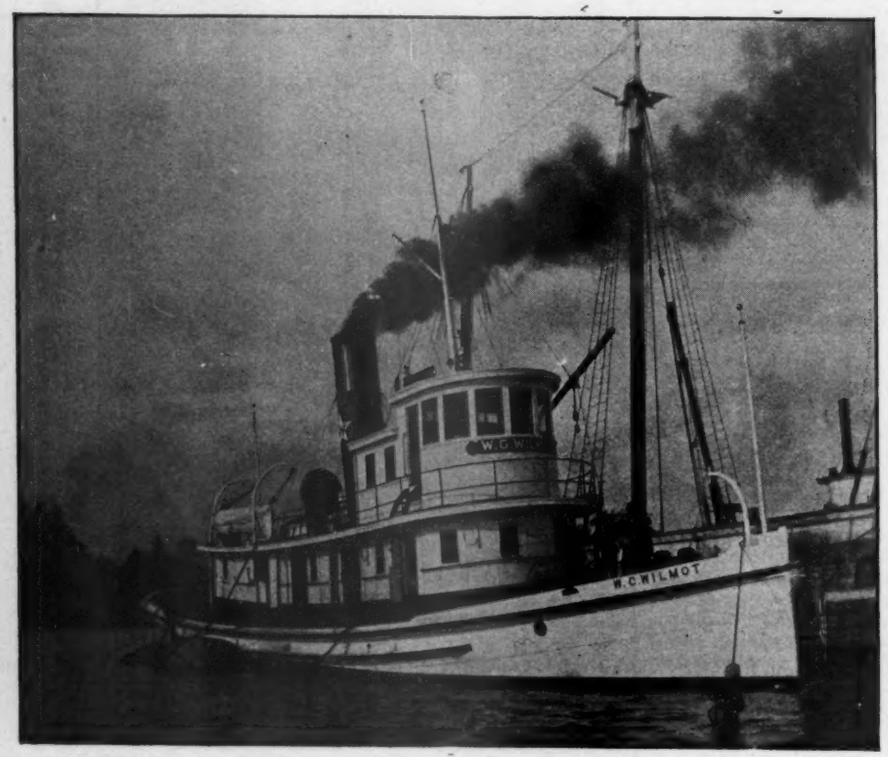
Other fairly established uses are for the links of chain elevators and for certain parts of safes. For the latter a material which can neither be drilled nor broken seems to offer exceptional advantages.

Of the many prospective uses of manganese steel I will notice but two, for armor plate and for car wheels.

Manganese-steel armor plates 2 in. thick have been tested under the conditions of actual warfare. From these tests it is calculated that, in order to offer the same resistance as a manganese-steel plate, a wrought-iron plate would have to be 77 per cent. thicker, and a carbon steel plate 48 per cent. thicker.

We cannot yet tell whether manganese steel in very thick plates, such as are used for the sides of war ships, would behave as well as it did in these trials; but they certainly seem to commend it for the light plates with which vessels' decks are armored, and for the light shields which protect the gunners.

For railroad car wheels we need a material which, like manganese steel, is so hard that it will not wear away under the friction of the brake-shoe, and yet is so tough that it will not break when it hammers under full load and at full speed against frogs and crossings.



TUG WITH PONTOONS ATTACHED.

Twenty-two manganese-steel wheels, 30 in. in diameter, on one of the New England railroads, ran from 131,499 to 188,179 miles, or on an average of 168,453 miles before the first turning.

This is nearly seven times the average mileage of chilled cast-iron wheels on this particular road, where the conditions are very trying owing to frequent stops, and the consequent frequent application of the brake. The mileage of these manganese-steel wheels is nearly six times the reported average life (29,074 miles) of cast-iron wheels on the Boston & Albany Railroad. The general belief is that chilled cast-iron passenger wheels, 33 in. in diameter, run on an average 60,000 miles before removal, which is about one-third the mileage of these manganese-steel wheels before their first turning.

The mileage of composite or steel-tired wheels is much greater than that of chilled cast-iron wheels, though the steel tire of the composite wheel is very much softer than the cast iron. That of 720 steel tired wheels on the Boston & Albany Railroad was 111,804 miles before the first turning; the average mileage of these manganese-steel wheels is thus 51 per cent. greater than that of these composite wheels before their first turning

The first cost of the manganese-steel wheel, which is a simple casting, is much below that of the composite wheel. The cost of the wheelage, or wheel service, consists mainly of the first cost of the wheel and of the interest on this first cost. Calculations which I have made, but with which I will not to-night trouble you, show that the manganese-steel wheel is likely to be much cheaper per 1,000 miles run than the composite wheel.

I believe that the manganese-steel wheel is not only incomparably safer than the chilled cast-iron wheel, but, all things considered, really decidedly safer than the composite wheel.*

Its enormous and extremely constant electric resistance, coupled with its cheapness, as compared with German silver and platinoid, should give manganese steel important applications in electrical engineering.

PONTOONING THROUGH THE ST. LAWRENCE CANALS.

We are indebted to the *Marine Record* for the accompanying illustration, showing the method in use for pontooning vessels through the St. Lawrence system of canals.

The tug *W. G. Wilmot* was built by F. W. Wheeler & Company, West Bay City, Mich., for the New Orleans trade, and as three lightships built to the order of the U. S. Light-house Board had previously been successfully pontooned by the device shown herewith, the builders of the *Wilmot* concluded that no more convenient and thoroughly reliable means to accomplish the purpose in view could be obtained than by ordering the same purchase to be applied to the tug, which, as soon as the order was received, was done, to the satisfaction of all concerned.

The draft of water through the canals, while nominally 9 ft., is subject to season fluctuations, and anything over this draft requires pontooning. With a knowledge of this fact, Mr. Lesslie, Manager of the Collins Bay Company, had two cylindrical-formed steel pontoons made, guaranteed to give a large buoyancy of lifting power, and with these pontoons placed alongside, it is only necessary to ballast them with water to a sufficient depth, secure them to and under the vessel, and then pump out the water until the required draft of the vessel has been reached, this having been done in the past several instances, besides leaving considerable spare buoyancy in the cylinders or pontoons, should it be required to raise the vessel any more during transit. The utmost success has so far attended the use of these steel pontoons, and it is expected that they will be largely used during the World's Fair season, as a large fleet is certain of making its way from Montreal to Lake Ontario.

With the development of commerce and ship-building, these and other similar appliances will no doubt be brought into more constant use during the season of navigation, and will form a no inconsiderable feature in the methods of transportation between lakes and seaboard. It is also possible that in the near future adjustable cradles may be used that will close in on the ends of a vessel and occupy no greater space than the beam of the vessel actually calls for; but, until more regular communication is established, it perhaps would not be a paying investment to fit out anything more intricate, elaborate or expensive than the steel pontoons now in use and doing such excellent service.

* A widely circulated statement of the number of steel tires broken on the railroads of the German Empire in the years 1884 to 1889, inclusive, reports many manganese-steel tires as breaking. But the term "manganese steel," as here unjustifiably used, refers to a wholly different material from that described in this paper; indeed, to a true carbon steel merely containing a little more manganese than usual, but I believe never more than two per cent.; certainly nothing like the percentage of manganese which would entitle it to be classed with the manganese steel forming the subject of this paper. Some of this pseudo-manganese steel, lately examined, contained only 0.60 per cent. of manganese.

A NEW LAKE STEAMER, THE "MANITOU."

THE Chicago Ship-building Company is at work on a new steel steamer, the *Manitou*, for the Lake Michigan & Lake Erie Transportation Company. It is built somewhat after the lines of the *Virginia*, illustrated in our May issue. Her keel length is 275 ft.; length over all, 295 ft.; beam, 42 ft.; depth to spar deck, 24½ ft.; to hurricane deck, 32½ ft. A water bottom 3½ ft. deep extends the entire length of the vessel, and is divided into eight compartments. In addition to this, seven steel bulkheads will separate the hold into water-tight compartments, which are calculated practically to render the craft unsinkable in case of damage through collision or otherwise. The power of the *Manitou* will consist of a triple-expansion engine with cylinders 23, 38 and 62 in. in diameter and 36 in. stroke, steam for which is to be supplied by two gunboat boilers, each 11 ft. in diameter and 21 ft. long, guaranteed for a working pressure of 160 lbs. An economizer of fuel is to be introduced in the shape of two Sturtevant exhaust fans placed in the base of the smoke-stack. Connected air, bilge and cold-water pumps, independent fuel pumps, and a feed-water heater are features of the machinery. The pistons of the engines will be of cast steel.

Particular attention is to be paid to the interior appointments, furnishings, etc., of the *Manitou*. According to the working designs, passengers will enter the boat on the main deck abaft the engine, where a sliding plate-glass door leads to a reception hall 24 ft. × 26 ft. On one side of this hall is the steward's offices, and on the other the office of the purser. All the facework in this reception hall is polished Mexican mahogany. A baggage-room, parcel-room, barber shop, wash-room, etc., will be found forward and aft of this hall. A broad mahogany stairway leads to the beautiful main saloon, whose 200 ft. of length is broken only by the machinery enclosures, light being obtained from domes over the hurricane-deck houses. The saloon is flanked by a double tier of state-rooms, with a gallery for access to the upper tier. The lower state-rooms obtain light and air through the medium of deadlights let into the sides of the steamer. The finish of the saloon combines uniqueness with elegance. It is mahogany below and white and gold above, with mahogany gallery railings and staircases—all stateroom doors being fitted with plate glass. Aft of the main saloon is a drawing-room 20 ft. × 22 ft. in size, leading out on the spar deck. The dining saloon is forward on the spar deck, extending the full width of the ship, being 43 ft. in length, lighted by large brass-bound deadlights at the sides and an oval dome overhead, and finished in red birch. The pantry is immediately forward of and adjoining it, and the galley, ice and store-rooms, etc., on the main deck below.

The promenade, which is located on the hurricane deck, is 275 ft. long, and ranges from 6 ft. to 11 ft. in width. It is entirely under cover and fitted with ample sitting requirements. The boats and life rafts are carried on steel bridges overhead. On the hurricane deck are located the ladies' parlor, 16 ft. × 17 ft., and a gentlemen's smoking-room, 15 ft. × 17 ft., which are finished in oak with handsome skylights. The captain's office and sleeping apartment are also on this deck. The portion of the crew belonging to the engineer's department is accommodated on the main deck abreast of the engine-room, and the remainder of the crew on the deck forward and on an orlop deck in the forward hold. The afterhold over the shaft alley is fitted up handsomely with berths for first-class passengers.

There are 120 staterooms for passengers, each fitted with marble washstands and running water, as well as electric lights to each stateroom. A number of the staterooms are of extra large size, finished in hardwood, with brass bedsteads instead of berths; two rooms will be fitted with lounges and Pullman berths, forming parlors during the day. Altogether about 400 passengers can be provided with first-class sleeping accommodations.

The *Manitou* will run between Chicago and Sault Ste. Marie, stopping at Mackinac Island and Harbor Springs, making two round trips each week. Her speed will be about 15 miles per hour.

The cost of the *Manitou* will be about $260,000.—*Evening Wisconsin.*

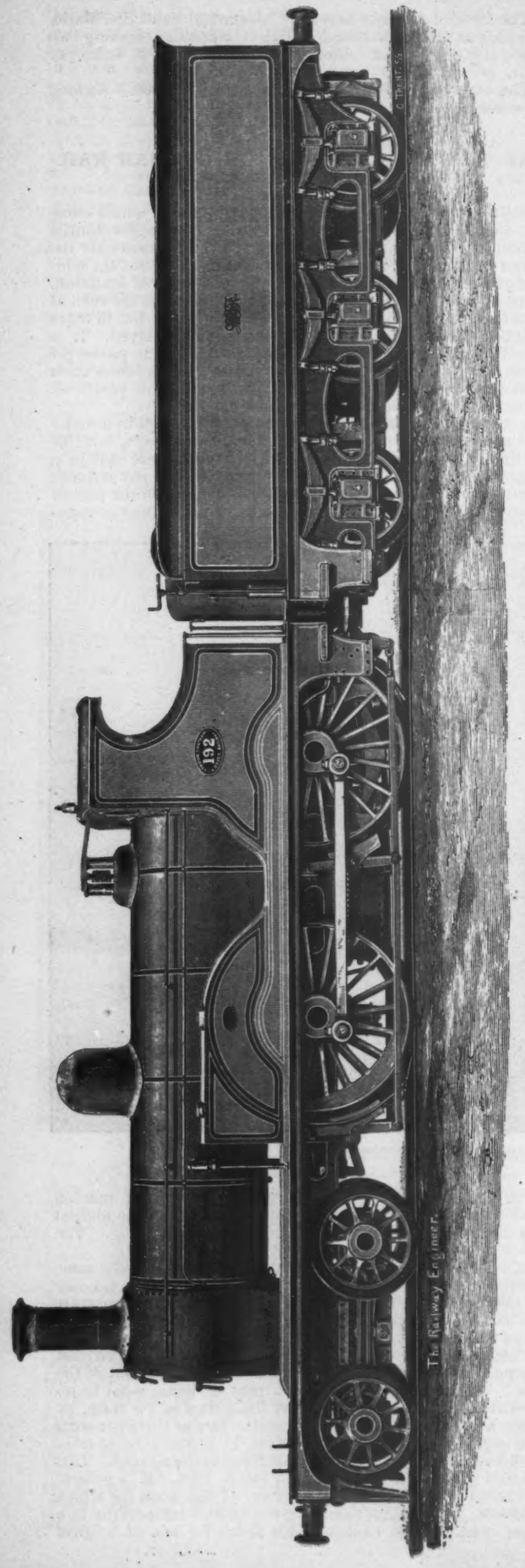
THE NEW REGULATIONS ON GERMAN RAILWAYS.

SOME of the new German railway regulations which came into operation a few weeks ago will strike the English tourist as peculiar. That they are useful and even necessary for the proper regulation of the traffic may be conceded, but the oddness of certain provisions is attracting a good deal of attention. Some of the rules are very commonplace, and some are such as have been observed on English railways for years, but in other directions considerable ingenuity has been displayed. It is difficult to understand why time tables relating to passenger traffic intended for stations of the railway which issues them must be printed on light yellow paper, while those posted on foreign lines must be printed on white paper.

It may interest English mothers to know that children under four years of age can travel free on German railways, but like the infants in the London omnibus, they must not occupy a seat. Children from four up to ten years of age pay reduced fares—a thoughtful provision, highly becoming on the part of a paternal government, which is the principal railway proprietor in the country. Should there be a conflict of opinion touching the age of children, the railway official of the highest rank decides the validity of the claim for the time being. The matter afterward forms the subject of official inquiry.

TUG RAISED BY PONTOONS.

As regards tickets, the system in Germany is much the same as our own. The tickets must indicate the name of the line and also the class and fare. Five minutes before the departure of a train the railways are not bound to deliver any more tickets for that train. The officials may decide that no change will be given at the booking office, and in consequence request passengers to hand in no sum greater than the amount of the fares. Whole compartments, or a part of them, must be secured at least half an hour before the arrival of the train, by paying a sum equal to as many times the fare as there are seats to be engaged. There must, however, be in the coming train a sufficient number of seats or compartments disengaged. This applies especially to sleeping and saloon cars. If a passenger cannot get a seat in any carriage of the class for which he booked, and no seat can be given to him temporarily in a higher class, he can exchange his ticket for one of a lower



EXPRESS PASSENGER ENGINE, LONDON, CHATHAM & DOVER RAILWAY.

class, and claim the difference in fare; or he may give up the journey and claim the reimbursement of the fare.

Where a passenger arrives at a junction station at which he has to change trains, in order to travel on another line, he is entitled to the use of the waiting-room, of the latter until his train arrives, and in the night hours between eleven o'clock and six in the morning he is entitled to stop in the waiting-room, provided, of course, it is kept open. Passengers are warned by the ringing of a bell when the time arrives to enter the train. Porters also call out in the waiting-rooms the names of the stations at which the train stops. There are some interesting regulations concerning smoking, which is forbidden in all first class compartments unless the whole of the passengers agree to it, but a compartment may be set apart for smokers as well as for non-smokers. A special compartment has to be reserved in each train for ladies, and it is needless to say smoking is absolutely interdicted there as well as in the non-smoking compartments. Smoking is allowed in all compartments of second, third, and fourth-class carriages. Recently, however, a recommendation has been made to set apart a second-class apartment for non-smokers. The regulations extend in some instances to the minutest particulars—for instance, pipes must be provided with lids to obviate the danger of flying sparks.

A traveler who misses his train is not, of course, entitled to compensation, but if the ticket was valid for only one special train he can, after obtaining the *visa* of the station master on his ticket, travel the same day by any train, or the next day by a similar train bound for the station indicated on the ticket. Should the fare by the subsequent train be higher the passenger must pay the difference, but should it be lower, the railway has to refund the difference.

Drunkenness at the stations and in the trains is sternly discountenanced. Drunken people must not be admitted into the waiting-rooms or the trains, but people ejected from the station will be refunded their fare and receive their luggage. If the ejection occurs at a station during the journey, the passenger is refunded a sum equivalent to the fare of the uncompleted portion of the journey; but the luggage which he might have had registered can only be returned at the end station. The same rule applies to people who behave indecently, and those who are afflicted with visible and repulsive infirmities, unless they travel in compartments specially set apart.

The penalties for traveling without a ticket are severe, but to the English traveler they will seem strange indeed. Any one discovered on a train without a ticket in his possession must pay double fare for the distance he or she has traveled. If the name of the station at which the trespasser entered the train cannot be ascertained double the fare for the whole distance the train is running must be paid. This amount must not be less than $1.50. Passengers who, of their own free will, inform the guard or conductor that they were too late to get tickets will only be required to pay the amount of the fare and a tax of 25 cents. The amount must in no case exceed the double fare, but whoever refuses to pay may be at once given in charge of the police. The regulations, I think it will be admitted, have just a slight flavor of the iron rule which obtains in Germany.—*Transport.*

EXPRESS PASSENGER ENGINE, LONDON, CHATHAM & DOVER RAILWAY.

We illustrate one of the new four coupled bogie express engines which the Vulcan Foundry Company have lately built for the London, Chatham & Dover Railway, to the designs of Mr. William Kirtley, Locomotive Engineer.

These engines work the fast expresses which run in connection with the continental steamers, and some part of the line is very heavy, but the ruling gradient is 1 in 100. The weight of the trains varies from 150 to 220 tons, and the time allowed for the 74 miles between Herne Hill and Dover Pier is 96 minutes, so that the average speed is 46.2 miles per hour.

These engines have worked very satisfactorily, and consume only about 32 lbs. of coal per mile.

The following are the principal dimensions and particulars:

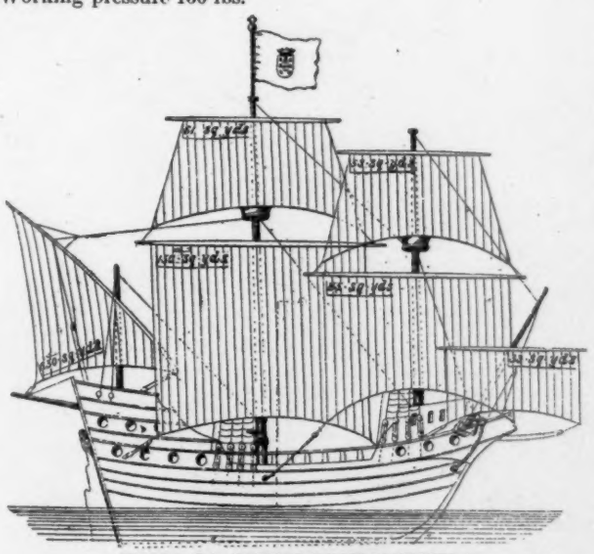
	Ft.	In.
Cylinders, diameter	1	6
" stroke	2	2
Steam ports	1½ × 1	3
Exhaust "	3½ × 1	3
Lap of valves		1
Max. travel of valves		3 1/16
Lead full gear		7/32
Throw of eccentrics		3½
Diam. of sheaves	1	4½
Between centers of cylinders	2	4

	Ft.	In.
Center of exhaust port to center of driving-axle	10	0
Crosshead pin ..... 3" diam. ×		3
Center to center of valve spindle		6
" " expansion links		7
Length of connecting-rod center to center	6	4
" eccentrics " "	4	10
Crank-pins ..... 7½" diam. ×		4
Piston-rod diam.		3
Frames (steel)—		
Thickness		1 1/16
Distance between	4	0
Length of frames	27	4
Width over footplates	7	10
Wheels (cast steel)—		
Diam. of driving and trailing-wheels	6	6
" bogie wheels	3	6
Tires, thickness		3
Distance of center of driving-wheel to center of trailing	8	6
Distance of center of driving-wheel to center of bogie	10	0
Center of bogie wheels	5	9
Total wheel base of engine	21	4½
Coupling-rod crank-pins ..... 4" diam. ×		4
Throw of coupling-rod cranks		11
Section of coupling-rod ends..1½" × 4" middle 1½" ×		4½

Axles (steel)—

	Bogie.	Driving.	Trailing.
Diam. of center	5½"	7"	7"
Bearings, diam.	6	7½	7½
" length	9	7½	7½
Wheel seats, diam.	7½	9	9
" " length	6½	7	7

Between center of bearings..3' 7" 4' 0" 4' 0"
Crank-axle webs. Inside 12" × 4½". Outside 12" × 4½"
Boiler (steel)—
Working pressure 150 lbs.



VASCO DA GAMA'S "SAN GABRIEL."

	Ft.	In.
Length of barrel, telescopic two plates	10	5
" " fire-box casing	5	11
Width	3	11
Diam. of barrel, largest	4	3
Depth of fire-box casing below center line	5	2
Thickness of plates in barrel		7/16
" " front and back casing		½
" " covering		¼
" " front tube-plate		7/8
Height of center above rail	7	2
Fire-box (copper)—		
Length inside bottom	5	3
Width	3	3
Depth	6	0
Top of box to inside of shell	1	3

Thickness of tube-plate 13/16" and ½"
" covering and back plates ½"
Tubes (copper)—
205 1¾" diam. outside.

Length between tube-plates	10	9 3/16
Diameter of blast nozzle		4½
Height of chimney from rail	13	3½

Heating surface—

Tubes	1,010 sq. ft.
Fire-box	110 "
	1,120 "

Grate area ..... 17 sq. ft.

Tender—

Wheel base	12	0
Diam. of wheels	3	9

Capacity of coal-bunker, 4½ tons.
" water-tank, 2,600 galls.

Weights—
Engine—

	Working order. Tons	cwts.	qrs.	Light. Tons	cwts.	qrs.
Bogie wheels	13	11	0	12	0	0
Driving "	15	13	3	15	11	0
Trailing "	13	4	1	11	7	0
Total	42	9	0	38	18	0

Tender—

	Working order. Tons	cwts.	qrs.	Light. Tons	cwts.	qrs.
Front	11	8	2			
Middle	11	10	1			
Hind	11	4	2			
	34	3	1	17	10	0

	Tons	cwts.	qrs.
Maximum weight of engine and tender in working order	76	12	1

—*Railway Engineer.*

VASCO DA GAMA'S SHIP THE "SAN GABRIEL."

THE rebuilding of the caravels as reproductions of the vessels composing the fleet of Columbus is soon to be imitated in Portugal, where a facsimile of the ship *San Gabriel*, in which Vasco da Gama discovered the sea passage to the East Indies in 1497, is to be built.

By the assistance of comprehensive data existing in the museums, libraries, archives, cloisters, and churches of the country, an accurate completion of the projected work is not outside the range of possibility, especially since the masterly reproduction by the Spaniards of the *Santa Maria*, which involved researches along a heretofore untrodden path of marine archæology.

The execution of the plan for the new *San Gabriel* was undertaken by Lieutenant-Commander and Hydrographic Engineer Baldaque da Silva and Emeritus Naval Constructor Joaquim José Salgueiro, who, after a lapse of four months, have come out with plans and a model of the ship.

The two investigators availed themselves of the assistance of a description of the *San Gabriel* published by Viscount de Juromenha in 1558, "The Lusiad" of Camoëns, in which the ship is frequently mentioned and a description of it is given; the "Voyages of Vasco da Gama," a book on shipbuilding and designing published in the sixteenth century, and especially the archives of the cloister of Madre de Deus and the city of Lisbon, the book of the Armadas and old Portuguese charts and instruction books.

In the short time since the inception of the work there has been an opportunity for settling upon the main outlines of the ship, though the projectors have not yet determined upon the details, which must necessarily be deferred; yet Señor Baldaque da Silva has published a pamphlet regarding the *San Gabriel* which, next to the Spanish work, "La Nao S. Maria," contains the greatest amount of valuable information regarding shipbuilding in the fifteenth century, and is the source from which the following description of Vasco da Gama's vessel is taken.

General Construction and Hull.—The form of the *San Gabriel*, which is herewith illustrated, is characterized by a long, projecting bow; a high, ornamented stern; a deckhouse fore and aft, and a strong outward swell just at the waterline. The hull bears the unmistakable stamp of marine construction at the close of the fifteenth century, to which we have already had occasion to refer in describing the *Santa Maria*. Inquiries have shown the *San Gabriel* to have been of the following dimensions:

Length over all	83 ft.	11.7 in.
" on water line	63 "	8 "
Extreme breadth of beam	27 "	10 "
Draft forward	5 "	6.8 "
" aft	7 "	8.8 "

From these figures it is calculated that the vessel had a displacement of about 178 metric tons. In old documents, on the other hand, the displacement of the *San Gabriel* is placed at 100 tons, yet this statement should have no weight, for there is no basis for the measurement that would bear investigation. In addition to the foregoing measurements taken from models and pictures, Messrs. Da Silva and Salgueiro have made use of the following data in their calculations:

Height of the metacenter above the center of gravity of displacement	9 ft. 8 in.
Height of the metacenter above water line (loaded)	7 " 4.5 "
Submerged cross section	15.4 sq. yds.
Sail area	444.5 " "
Area enclosed by water line	144.7 " "
Height of center of sail area	65 ft. 3 in.
Center of sail area forward of amidships	4 " 6 5 "

The 178 tons total displacement of the *San Gabriel* would, according to these measurements, be made up as follows:

Battery (20 guns)	6.48 tons.
Ammunition	6.00 "
Masts and sails	8.00 "
Boats and rigging	.70 "
Two anchors and one spare anchor	1.50 "
Hawsers (131 fathoms)	5.00 "
Water supply for 120 days	19.60 "
Provisions for 120 days	21.00 "
Crew (50 men)	3.25 "
Weight of hull	92.00 "
Miscellaneous stores and ballast	14.47 "
Total	178.00 tons.

The vessel had a single deck extending over its whole length, and which, as will be seen from the engraving, had but a single hatchway amidships, while deckhouses were built on the forecastle and quarter-deck. A protective deck was built upon the forecastle for the purpose of sheltering the guns, while the cabin standing on the quarter-deck afforded the only shelter on board for the quarters of the admiral or commandant.

Between decks there was nothing but the deck timbers, the object of which was to serve as braces for any sides or platforms that might necessarily be constructed for the reception of a cargo taken on board.

The main-deck carried the principal battery, which, as is shown by the engravings, was arranged to fire from either bow and on either side of the quarter-deck, while the remainder of the guns were placed in the cabin.

On the lower portion of the main-deck there was a sort of standing place from which the vessel was navigated. On either side of this place there was a small gang-board which also served as the rail, and extended the length of the depression amidships.

It was beneath this gang-board that the watch on deck sought shelter from the weather while the watch below slept in the forecastle.

The space beneath the quarter-deck was reserved for the ship's officers and their equals who might take passage on board. The ship's hold was divided into three compartments, the one amidships being reserved for the storage of water-casks, provisions, and cordage; the after one for the accommodation of ammunition, while the one forward served for the use of the carpenters and sailmakers. There was also a small space reserved for the storage of wares intended for barter and gifts.

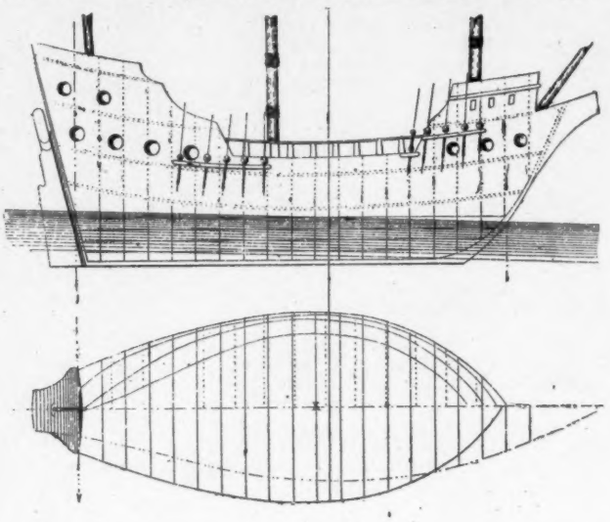
Regarding the construction, it may be mentioned that the vessel was built of carefully selected, sound timber, which was firmly bound together with iron bolts.

The framing extended only up to the scuppers of the main-deck, and extended from there to the top futtocks. It was formed of two courses bolted together. The form of the cant frames and fashion pieces must have been of a very primitive design, so that the vessel would have been very seriously hampered thereby. The sternpost tapered from above downward, and the top timbers of the fashion piece were upright as they corresponded to the form of the poop-deck. The inner planking was very securely fastened, for it was only by this that the deck timbers were held. Likewise the outer planking as well as the mainwale and sheer-rail was most firmly secured. The forward end of the outer planking was let into a gaining in a false stem and aft in the sternpost; the space between the planking was caulked with wooden strips.

Along each side of the vessel there were three strong fender timbers. The fore and mainmasts had chainwales and irons, such as are used at the present time.

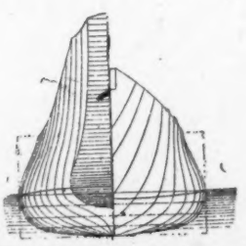
For ornamentation the hull carried a figure-head representing the Archangel Gabriel with arabesque carvings on the prow and stern. The main works were coated with pitch as a protection against water, while the hull was painted outside with ochre and inside with oil paint.

Masts and Sails.—The vessel had three masts and a bowsprit, and for sails a spritsail, two courses, two topsails, and a lateen-shaped spanker. The mainmast was a single stick, well banded, carried on short wedges, and reaching down to the keelson. It was stayed by four shrouds on either side, which were tightened with dead eyes and lanyards. In addition to this it had a double backstay which passed through an eye at the upper end and was tightened below by a lanyard. The foremast was shorter than the main, and differed from that on the square-rigged caravel of Columbus in being stepped further forward. In rigging it only differed from the mainmast in having a single backstay, which was led through a deadblock and fastened to a second deadblock attached to the bowsprit. The spanker mast was shorter and lighter than either of the other two, and went down through the cabin with a step on the quarter-deck. It was stayed by shrouds on either side and also by a stay to the mainmast. The bowsprit was a single stick set at a very steep incline; it rested on a bolster and was held inside by a foot; the spritsail yard could be run in and out. Both topsails had a swallow-tail shape, and this served principally to keep down the bellying of the closed portions of these sails. The topsails were held by three sheets and a backstay on each side in addition to a mainstay;



VASCO DA GAMA'S "SAN GABRIEL."

The low line of the plan is the load water-line.



the prolongation of the fore-topsail stay formed the second preventer stay for the bowsprit. The construction and rigging of the upper spars is not worthy of any particular remark, unless it were to call attention to the spanker-gaff, which is attached to the after side of the mast, and was held by a down-haul, two sheets, and two halyards, the inner one of which ran through a block at the top of the mast, while the outer one was rove through a block fastened at the head of the mainmast.

The arrangement, form and area of the sails are given in the sail plan, as illustrated; in connection with which it may be remarked that the spanker-sheets were made fast to a rigid spanker boom. All the sails were provided with clew-lines, so that they could be clewed up in brails, while the lateen-sail alone, which formed the spanker, could be reefed. Sail was shortened, then, while all or a portion were clewed up.

Two so-called bonnets, which were a kind of lee-sails, were attached to the courses, and were fastened below the bolt-ropes. The sheets were so arranged as to clear, in case of necessity, the clew-lines of the mainsail and those of the bonnets.

Bowlines were provided for all of the square sails of the main and foremasts. The four lower sails carried the sign of the cross, in order to distinguish the vessel as a Christian ship, according to the usage of the day. Cotton duck with a width of 26¾ in. was used as a material for the sails.

Armament and Special Equipment.—As the 20 guns forming the armament of the ship only weighed 6.48 tons, each piece must have been quite small. The battery located on the main deck consisted of 12 muzzle-loading lombardos, which fired either stones or lead-covered iron balls, and were attached to wooden carriages, by which a variation in horizontal fire but no change in the elevation of the piece could be made. Six other pieces belonged to the class of so called falconets.

It does not seem probable that these falconets, which had trunnions and lay in stiff, forked bearings, were located in the cabin, as the Portuguese sketches would indicate, since they were usually placed upon the spar-deck. The vessel had two bow and one reserve anchor on board. They were made with wooden stocks and large rings for fastening the cables. The capstan for winding in the cable stood abaft the mainmast. The rudder had a form which is still found on the coast of Holland and also in some of the coasting vessels of the Mediterranean. As its head lay back of its center of revolution, an oblong-shaped opening had to be made in the poop-deck for the spindle. In bad weather or a fresh wind a tackle was used for steering. The safety of the rudder was insured by rudder-pendants with their chains.

There was only one bilge-pump on board, which was located just forward of the mainmast. The galley was built of tiles and, for the protection of the main-deck, upon which it stood, it had an earthen floor.

The fixed ballast consisted of large stones and cast iron, yet in case of necessity broken stone or sand was taken on board in default of the requisite weight of stores. The ship flew a large white flag from the main-top, and, while under the command of Vasco da Gama on the high seas, a long, red pennant floated from the main topsail, showing that an admiral was on board.

In conclusion, this description is wanting in that our readers will have to imagine many details added to this summary of a celebrated Portuguese ship. We think, moreover, that when the new *San Gabriel* comes to be built it may differ in not a few particulars from the outlines as we have described them.

It is very probable, too, that the truth will make but very little change in the dimensions as given by the Portuguese investigators, since it is more than likely that they are correct. It is also well known that the celebrated *Victoria*, which made the first voyage around the world, had a smaller tonnage than the *San Gabriel*, from which it may be clearly understood that in the fifteenth and sixteenth centuries men did not hesitate to make long voyages upon the high seas in small vessels.

These vessels were really handicapped by the abnormal height of the metacenter, so that, in short, they were not suited for deep-sea voyages, although they stood well on the long waves of the ocean; still their light draft made them more especially suitable for navigation along a protected coast and in rivers; then they presented this advantage that they could be practically dry-docked with the aid of the tide when any repairs were required on the hull.—*Mittheilungen aus dem Gebiete des Seewesens.*

GERMANY'S NEW ARTILLERY.

So destructive in its effect is the new German artillery that it is asserted, once the range were found, a battery would annihilate an entire division in a very short time. *Prima facie*, this seems rather to border on the impossible; but when the results of the experiments which were recently made in the presence of the emperor with the new weapons are considered, the task does not appear to be so impracticable after all. The first shot fired in the course of these experiments was at a target placed 50 paces from a wood. The missile missed the target, but plowed its way for 500 yards through the wood. Shortly afterward a large area of the wood was discovered to be on fire. This was due to the shell being charged with a certain kind of powder, the composition of which is a secret known only to the German Government. The splinters from shells burst by this powder and fired by the new gun cover a circle of 900 ft. This is a great improvement on the limited area of ground that was covered by splinters from shells fired by the artillery weapon of 20 years ago. Then it was considered effective shooting if splinters from a shell were thrown within a circuit of 40 or 50 paces, and seven or eight men wounded; but the new gun has a far greater destructive power than this. Another shell fired at an enormous target, constructed by the emperor's orders, covered it with thousands of holes.

The new German field gun might, perhaps, be better described as an enlarged rifle, for that is what it really is. The ammunition, like rifle cartridges, consists of one piece only. Ignition is produced by a ready fuse, and the four kinds of projectiles at present in use—*i.e.*, shell, explosive shell, shrapnel and grapeshot—give place to a uniform projectile, an explosive shell, possessing the combined characteristics of shell and shrapnel. Thus the possibility of a gunner mistaking in the heat of battle one projectile for another will be averted, while the loading, aiming and firing, besides being quicker, for the new arm is loaded and fired in one-third of the time required in working the old gun, and the effect and precision are almost double, will be surer and unattended with danger. The barrel of the new gun is made of cast steel, with a caliber of eight centimeters, and the total weight of the gun, limber and carriage is slightly less than that of the old artillery weapon. Being lighter, the mobility of the new gun will, of course, be considerably increased. The limber and gun carriage are made of iron and iron plates. The limber box is open behind near the gun when in action. The advantage of this innovation is that the projectiles can be served from the limber and ammunition wagon with greater rapidity. Another important feature is that the carriage is supplied with a brake, which counteracts the recoil, the process of loading and firing being thus simplified.—*London Court Journal.*

PASSENGER CAR EXHIBIT OF THE HARLAN & HOLLINGSWORTH COMPANY AT CHICAGO.

THE Harlan & Hollingsworth Company, of Wilmington, Del., have on exhibition at Chicago three cars which may be taken as types. One of these, which is not illustrated, is a special car of the Mann *boudoir* pattern, and has been built for the use of the officers of the Ferra Carril de Bahia al Noroeste, in the Argentine Republic. Its compartments are a dining-room and parlor, at opposite ends of the car, with a stateroom, kitchen, pantry, bath and toilet-rooms occupying its central section. The general tone of color of the interior of this car is yellow, the finish is in oak and the upholstered hangings are of old gold. It is lighted by the Pintsch gas-light system. Its dimensions are: Length of frame, 54 ft.; length over platform, 61 ft.; width of frame, 10 ft.; spread of wheels on truck, 7 ft. 10 in.; diameter of wheels, 3 ft.

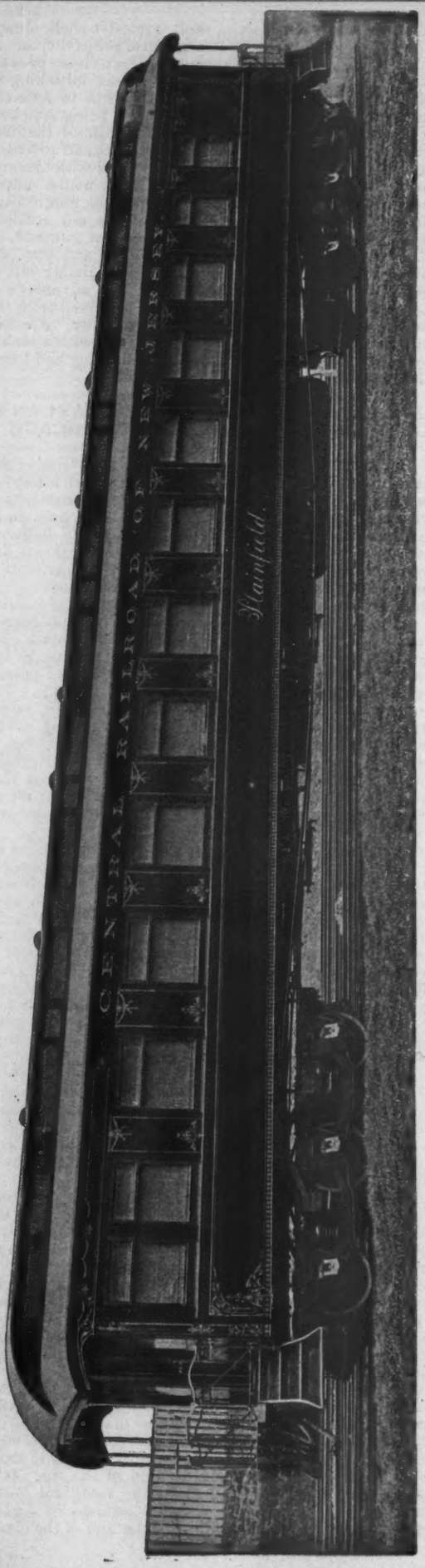
The other two cars, illustrations of which are given, represent over half a century of progress in car building. The relative length of the two cars, as given by the engraving, is approximately the same as the actual lengths of the originals. The difference between the two cars is even greater than that appearing in the engravings; the older one being the representative of the early stages of the art, while the new one embodies the latest improvements of refinement and luxury.

The original car is too small to be run in modern trains on its own wheels, and was therefore shipped on a platform car as narrow-gauge cars or street cars are shipped. Its dimensions are as follows: Length of frame, 32 ft.; length over platforms, 37 ft.; width of frame, 8 ft. 6 in.; spread of wheels, 4 ft. 9 in.; diameter of wheels, 2 ft. 9 in. In shape it is simply a box, nearly square on its cross-section, containing about a dozen double seats fixed back-to-back and arranged along one side with one long seat along the other side, on which the passengers sat with their backs against the car wall and their feet toward if not in the aisles. The seats are upholstered in gray hair cloth. Crowded full this car would accommodate about 40 passengers. The windows are narrow, stationary single panes of glass, and ventilation is provided for by a movable panel 6 or 8 in. wide at the end of each of the cross section seats. The side walls and ceiling are simply of beaded siding and are painted a light drab; the floor is of common stock boards, not matched, laid lengthwise the car and painted lead color. The outside of the car is painted yellow and is entirely without ornament.

The car which stands opposite this one, as the result of half a century's effort in evolving a perfect railroad coach, is the club car *Plainfield*, built for service on the New Jersey Central Railroad, and for the use of a number of business men of Plainfield who do business in New York City.

This car is the realization of all that a refined and luxurious taste could desire in a coach. The body of the car is painted a very dark blue with ornamentation in gold. It is carried on two six-wheeled trucks. The steps at each end are of easy ascent, the platforms wide, and all the hand-rails about them are of polished brass.

This car is divided into two compartments by a bulkhead across its center, and is finished in mahogany—the walls, bulkhead, doors, tables and chairs being of that wood, and all exquisitely carved and finished. One end contains a heater-room, a linen locker, a saloon and a lavatory. Next to these small apartments is the first main division of the car. It is about 30 ft. long, 8 ft. wide, and under the ventilator about 9 ft. in height. The sides are alternate sections of highly finished mahogany wood, of a dull red color and of the clear-



CLUB CAR BUILT BY THE HARLAN & HOLLINGSWORTH COMPANY.—WORLD'S COLUMBIAN EXPOSITION.

est plate glass; the glass sections, twice the width of the wood, make the car very light and pleasant. The ceiling is of oak, painted in yellow, brown and gold in colonial designs. The wood section of the walls between the plate-glass windows are composed of two turned columns of mahogany, with handsome carved capitals, enclosing a beveled mirror, and behind the mirror—between each pair of windows—is a locker, the mirror being the door of it; the frieze is a handsomely carved belt of mahogany, encircling the car; along the frieze and over each locker is an oxidized package basket.

The furniture consists of 10 tables fixed along one side of the car with four revolving chairs at each table, six or eight big arm chairs along the other side, and several willow chairs about the ends of the car.

There are no upholstered hangings; except the curtains at the windows, the chairs are upholstered in red-brown leather, and the carpet is soft, of the same general tint with sparse

EARLY PASSENGER COACH BUILT BY THE HARLAN & HOLLINGSWORTH CO.—WORLD'S COLUMBIAN EXPOSITION.

dots of deeper color strewn over the surface. The bulkhead of mahogany incloses a circle of plate glass immediately over the door, two circular topped windows, one on each side of the door, and a big rectangular pane of the same quality of glass forming the upper portion of the door. The wood-work about the glass is decorated in beautifully cut figures.

The entrance at the opposite end of the car is through a semi-circular, dome-capped vestibule. The outer walls and the ceiling of this vestibule is paneled mahogany; the walls inside the car and the outside of the dome roof is beautifully carved in floral designs, the figures being in low relief; the door contains panels of plate glass and its hardware is of oxidized silver. The car is lighted by the Pintsch system of gas lights, and each compartment is lighted by three lamps suspended from the ceiling.

The dimensions of this car are as follows: Length, 71 ft. 6 in.; length over platforms, 78 ft. 1 in.; width, 9 ft. 6 in.; spread of wheels, 10 ft., and diameter of wheels, 3 ft.

CONDENSATION OF STEAM IN STEAM-ENGINES.

By B. Donkin, Jr.

There is little doubt that the "forms" of single, compound, or triple engines have a good deal to do with steam condensation, particularly as these forms generally mean considerable cold areas of condensation in contact with the hot steam. The steam temperature range in each cylinder has, according to experimental results, much less influence than the temperature of the metal. When cylinder walls are heated till their temperature equals that of the steam, there is less condensation per square foot of internal surface than with non-heated walls. The indicator diagrams show that the pressure and temperature ranges are increased; so that as compared with cooler surfaces, there is *less* condensation and *greater* range, and experiments confirm this.

Take the case of two modern triple engines by two different makers. Even when made for about the same power, steam pressure, and speed, they differ considerably in their clearances *plus* passages, and also in their volumes, particularly in the extent of the hot or cold internal surfaces. This is probably one reason why similar engines give often very different results in the weight of the steam per indicated horse power per hour.

The extent of the metallic areas touched by the steam and their temperature has not, I think, been sufficiently considered hitherto, and they have a large effect on condensation.

The experiments at Bermondsey prove that non-heated iron surfaces, with non-superheated steam, produce a large condensing effect. Then besides the temperature and extent of surfaces, experiments show the importance of the heat penetration per stroke into the metal walls. This is greater the lower the temperature of the metal, and much less with hotter walls, say with steam jackets or superheated steam. The temperature holes in the metal walls bring this out clearly. With non-heated walls the penetration per stroke may be taken, say, at about $\frac{1}{4}$ in. and less, depending on speed or time of exposure, etc. We therefore have a certain weight of metal heated and cooled per stroke at the expense of the steam, say, 100° F. range at the surface, and no range at $\frac{1}{4}$ in. deep. This means the formation of so much water per stroke. So many pounds of iron heated up so many degrees means so many T.U. per stroke lost by the steam and water produced.

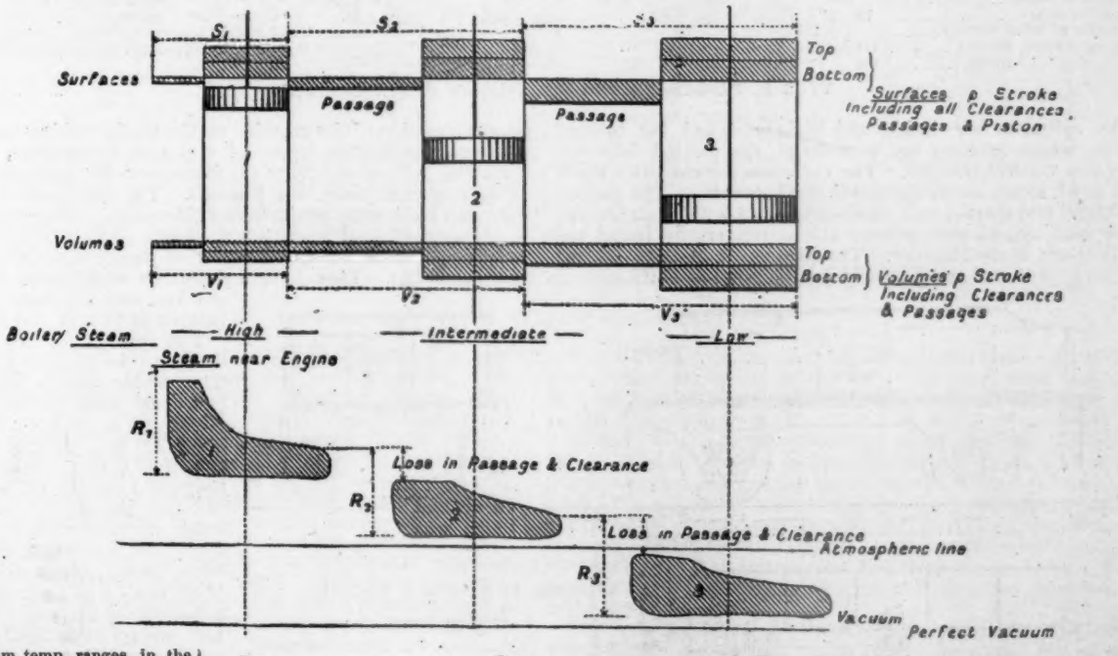
Before a piston moves at each end of each cylinder, condensation on all the boundary walls takes place at constant volume, and the maximum condensation occurs during this time. The steam is at its hottest or maximum pressure, and the metal at its coolest or minimum temperature. This shows the importance of experiments on condensation at constant volume, irrespective of power, with different surface conditions, the internal area and temperature of metal being known.

I add the calculated volumes and surfaces of three different types of engines—single, double, and triple. Perhaps others will help in this direction, and give some actual figures, which are seldom easy to obtain. A sketch of a triple engine is added, showing in a diagrammatic form the range of steam temperature in each cylinder, the depth of heat penetration per stroke into the metal, etc.—*The Engineer*.

Comparison of Volumes and Surfaces Exposed to Steam in Single-cylinder, Compound and Triple Engines (90 to 95 per cent. of stroke taken as release).

	Volume. cu. ft.	All surfaces. sq. ft.		sq. ft.
(1) Small *Single-Cylinder Engine*—(6in. diam.), indicating some 8—10-H.P.	0·130	2·09	or for 1 cub. ft. vol.	16·1 surface.
(2) *Compound Engine* (indicates some 50 to 60-H.P.—				
H.P. cylinder	3·057	16 36	or 1 cub. ft. vol.	5.35 surface.
L.P. cylinder	13·270	38·46	Ditto.	2·90 "
(3) *Triple Engine* (indicates some 200-H.P.)—				
H.P. cylinder	2·454	17·1	or 1 cu. ft. vol.	6·97 surface.
I. "	5·128	25·4	"	4·96 "
L.P. "	14·315	47·3	"	3·90 "

These figures include the volumes and surfaces generated by piston, and all clearances and passages between cylinders, also surfaces of pistons.



Steam temp. ranges in the cylinder and passages ..	R_1^s ———	R_2^s ———	R_3^s	degrees.
Depth of heat penetration per stroke into metal in parts of inches	D_1 ———	D_2 ———	D_3	parts of inches.
Weight of metal heated up and cooled down per stroke, including all clearances and passages	W_1 ———	W_2 ———	W_3	lbs.

lbs.

In each cylinder W × mean range of metal R^m × sp. ht. = T. U. per stroke taken from steam and water produced.

Mean temp. / Range of metal.	R_1^m ———	R_2^m ———	R_3^m deg.	The mean temp. range of metal is different from steam range.
Feed-water: Wt. steam p. stroke, as per diagram	Steam$_1$ ———	Steam$_2$ ———	Steam$_3$	lbs. feed-water p. stroke, about same weight of mixture in each cylinder ....
Feed-water: Wt. water per stroke by difference	Water$_1$ ———	Water$_2$ ———	Water$_3$	

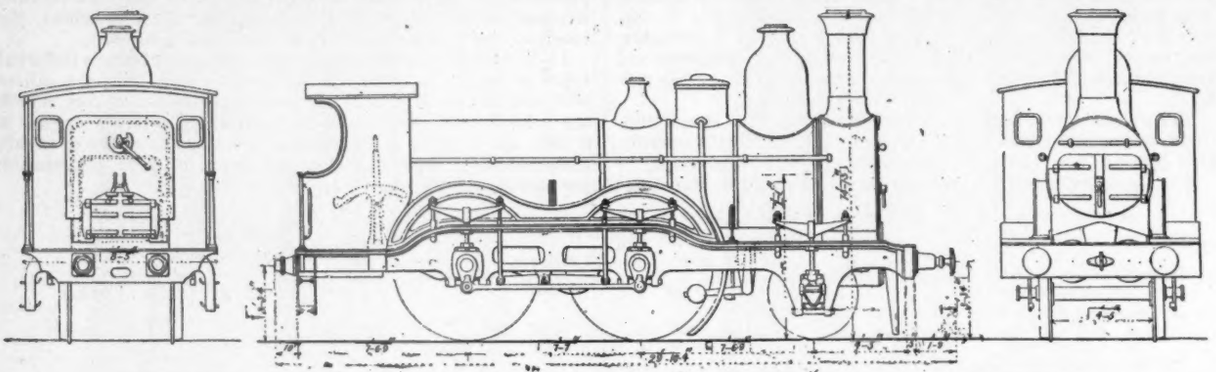
ORDINARY TYPES OF BELGIUM STATE RAILWAY LOCOMOTIVES.

By G. Braet.

PASSENGER LOCOMOTIVES.

There are several different types of passenger locomotives in use on the State railways of Belgium, which may be said to be distributed through two classes: those with four wheels and those with six wheels coupled. The four-coupled engines embrace the ordinary passenger locomotives (type 1), light locomotives (type 5), and express locomotives. Those with six coupled wheels are: ordinary locomotives with six wheels (type 2), 10-wheeled locomotives with tender (type 4), heavy locomotives for grades (type 6).

The ordinary passenger engine (type 1) has six wheels, of which four are drivers and two belong to a forward truck. The rear driving-axle is beneath the fire-box, and the diameter of the driver-wheels is 2 meters, or 6 ft. 6.7 in.



DIMENSIONS.

Diameter of cylinders	16.8"
Stroke of pistons	20.4"
Average diameter of boiler	4' 2.6"
Number of tubes	208
Length of tubes	10' 2"
Diameter of tubes outside	1.77"
Heating surface, firebox	114.5 sq. ft.
" " tubes	860 "

DIMENSIONS.

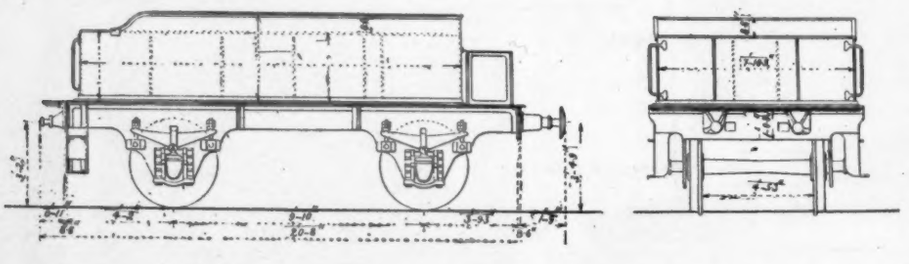
Total heating surface	974.5 sq. ft.
Capacity of the boiler	1,260 galls.
Weight on wheels, forward truck	2,060 lbs.
" " " main driving	29,547 "
" " " trailing	29,215 "
Total weight in working order	60,822 "
Weight of the locomotive, empty	68,465 "

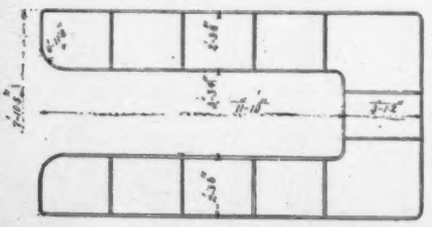
TYPE I., PASSENGER ENGINE, BELGIAN STATE RAILWAYS.

The cylinders are inside and horizontal, and the bronze valves, whose surfaces are very large, are located between them in a vertical position. The cylinders are cast with their back head, steam-chest, and guide brackets solid. The guides are lateral and double with cross-heads cast with a mixture of 2 per cent. tin, an arrangement almost universally found on the Belgium State Railway. The pistons are of the "Ramsbottom type," and are generally made of bronze, attached to steel piston rods, although the last pistons furnished are made of cast iron.

Steam is distributed by the Stephenson system, with the lifting shaft below, the link-operating mechanism consisting of a reverse lever working the lifting shaft. The different points of the steam distribution are marked upon a quadrant, and the lever is fixed rigidly in any position by a screw and nut. This arrangement for varying the cut-off is used almost exclusively on all the State railway locomotives. Here, as in all Belgian engines, the valve-rods are guided by bronze bushings pressed into the steam-chest; that portion of the rod which runs in this guide is cylindrical.

The eccentrics are of wrought iron made in two pieces, and are keyed to the axle; the eccentric straps are also of wrought iron, and are held together by bolts with a copper shim in between them, which permits them to be drawn together as they wear. All the eccentrics of the Belgian engines are of the same type. The exhaust is variable at the will of the engine-driver. The axles are of steel, but crank-axles of iron are also used, when the iron is of first-class quality. Spoked wheels of wrought iron with no counterbalance are used. The tires are of Bessemer steel with a thickness of 63 mm. (2.47 in.) when new. Those on the front and back wheels have a width of 140 mm. (5.5 in.), those of the driving-wheels are only 135 mm. (5.3 in.) wide, so that the distance between the inside of the driving-wheels is 1 cm. (.39 in.) greater than between those on the other axles. This arrangement facilitates the motion of the machine on the track, and has received a general application upon all types of locomotives. The truck-axle is fixed rigidly to the frame, and the engine is hung on eight springs above the journals. The springs of the forward and back axles are identically the same. They are made of 13 leaves of steel, each 100 × 10 mm. (3.93 × .39 in.), and their length from center to center of hangers measures 900 mm. (35.43 in.). They have a deflection of 8.4 mm. (3.3 in.) per ton, and are made with a camber of 61 mm. (2.4 in.).





TENDER FOR TYPE I. ENGINE.

Dimensions.

Capacity of tank	1,982 galls.
" " coal chamber	7,038 lbs.
Weight upon forward wheels	24,476 "
" " back "	23,153 "
Total weight in running order	47,629 "
Weight of tender, empty	23,153 "

The springs of the main driving-axles are of two kinds. The outside springs are composed of nine leaves, each 900 × 100 × 10 mm. (35.4 × 3.9 × .39 in.), with a deflection of 13.6 mm. (.53 in.) per ton, and a camber of 59 mm. (2 3 in.); the others which are inside are made of five leaves, 780 × 100 × 10 mm. (30.7 × 3.9 × .39 in.), with a deflection of 13 mm. (.5 in.) per ton and a camber of 51 mm. (2 in.). The springs of the back axles and the outside springs of the main driving-axles are coupled together by means of an equalizing lever.

The upper portions of the journal-boxes are of wrought iron, the lower portions or cellars being cast; they move between two guide-plates of cast iron with which 2 per cent. of tin has been mixed; the wedge is of steel and is made so as to adjust them for their own wear and that of the driving-wheels.

The crank-pins, side-rods and main rods are rectangular and of wrought iron. The main rod has strap ends for the pin and the cross-head, while the side-rods have solid ends.

The front buffer is made of oak.

The fire-box is of the Belpaire type. The advantage accruing from the use of these fire-boxes with semi-bituminous coals is no longer disputed upon the State railways, nor upon other lines which have made any tests with them. The one under consideration is 2.7 meters (8 ft. 10.29 in.) long by 1.08 meters (3 ft. 3.6 in.) wide, and is made entirely of red copper. The outer shell is square and is made of a sheet of No. 4 iron, which is 13 mm. (.5 in.) thick; the sheets are held together by copper stay-bolts 22 and 25 mm. (.86 and .98 in.) in diameter, 10 cm. (3.9 in.) apart; the crown-sheet is stayed by iron stay-bolts screwed and bolted to the outside sheet.

The shell of the boiler is of No. 4 iron, 13 mm. (.5 in.) thick, rolled into a perfectly cylindrical form, and is composed of three sheets. The horizontal seams of each sheet are double riveted, with a welt having two rows of rivets; the vertical seams are formed of a lap 130 mm. (5.1 in.) wide, with a single row of rivets; furthermore, all the vertical joints, as well as horizontal ones, are double riveted, with a welt along the line of the horizontal seams. A sheet of No. 5 iron is used to attach the shell to the outside of the fire-box. Strong stays attach the front end of the outer shell of the fire-box to the cylindrical portion of the boiler, and the side walls of the same are stayed across above the crown-sheet; the tube-sheet of the fire-box is also attached to the shell by means of six stays. The boiler rests upon the frames at three points: one at the cylinders, and by two plates which carry the fire-box on either side.

The tubes are of brass (70 per cent. copper and 30 per cent. zinc), 2.5 mm. (.09 in.) thick and 45 mm. (1.77 in.) outside diameter; they are provided at each end with iron or steel ferrules for making a tight joint with the two sheets. The two sheets forming the smoke-box are of No. 5 iron, while the sheet at the bottom, which protects the cylinders against the corrosive action of the gases, is of copper.

In most locomotives of the Belgium State Railway the smoke-box door is of two flat pieces. The engines are provided with no arrangement for preventing sparks from being thrown out of the stack, a netting and perforated plates having been tried with but little success. The mud-ring is of a single piece of wrought iron, and, where it is practicable, there are manholes for cleaning out the boiler. The management of the Belgium State railways have now done away with the use of these openings, the use of which has not been found to be indispensable.

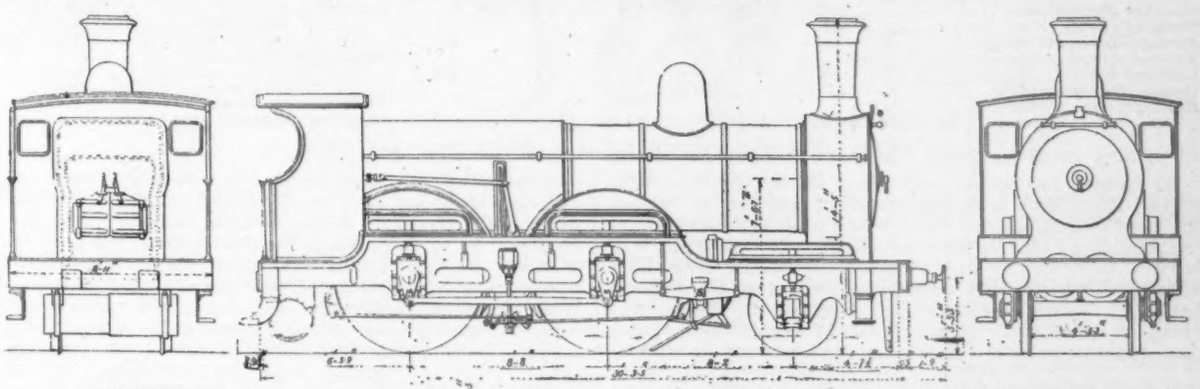
The fire-box door is made in two pieces which open separately. These doors were formerly made of cast iron, but are now made of two sheets of wrought iron 13 mm. (.5 in.) thick, provided with a guide by means of which the fireman can admit air at pleasure to cool off the surface exposed to the action of the flame.

The ash-pan is inclined at an angle of 30°, and has two openings of 32 × 1,000 mm. (1.96 × 39.37 in.) for the removal of ashes and the admission of air, as well as one variable opening of 190 × 1,000 mm. (7.48 × 39.37 in.) at the front end. The grate is partly fixed and partly movable, and has an arrangement of dumping the fire which is located next to the tube-sheet.

A hand-wheel conveniently located for the engineer permits him to shake the moving grate. It is by dumping through this opening that the clinkers and ashes are removed. The boiler has two openings in the shell: one carries the safety-valve seats, the second makes a communication between the boiler and the steam-dome. The dome has the manhole which is taken off when the boiler is to be inspected. The unlocked safety-valve is operated by the spring balance acted upon by means of a lever; it is pressed down directly upon its seat by a plate spring. The steam is taken from the top of the dome; the two valves which control the admission of steam are vertical, and are operated by levers keyed to the same shaft, an arrangement found upon most all of the Belgian State engines. The double valve has given very good results on account of the facility with which it can be handled and the dryness of the steam. The engines are also provided with a whistle which takes steam from the top of the dome.

The feed-pumps have been removed from the boiler, two injectors being used in their stead which are of the Schau, Rongy, or Friedman design. These injectors are of the non-lifting type. The feed pipes enter the boiler ahead of the fire-box and about two-thirds of their length down the shell; the check-valve is placed in the pipe just where it enters the boiler. By means of a very simple arrangement it is easy to heat the water of the tender by using the same steam opening which delivers steam to the injectors.

The sand-box is on the shell between the two safety-valves. Two copper pipes carry the sand down and deliver it in front of the main driving-wheels. The boiler has one glass water-gauge, the usual water-cocks and a metallic steam-gauge. Some locomotives of recent construction have two water glasses.



DIMENSIONS.

Diameter of cylinders		17.1"
Stroke of pistons		24"
Diameter of boiler	4'	3.2"
Number of tubes		225
Length of tubes	4'	11.4"
Outside diameter of tubes		1.77"
Heating surface, firebox	123	sq. ft.
" " tubes	1,176	"

DIMENSIONS.

Total heating surface	1,302 sq. ft.
Capacity of boiler	1,612 galls.
Weight of forward wheels	26,769 lbs.
" " main driving wheels	31,730 "
" " trailing wheels	31,642 "
Total weight in running order	90,141 "
Weight of locomotive, empty	81,585 "

EXPRESS LOCOMOTIVE, BELGIAN STATE RAILWAYS.

The locomotives are oiled by automatic lubricators which work when the steam is cut off. The lubricators used are those of Kessler, Henrotte and Furness, and are located on the front cylinder covers.

Several locomotives, especially those hauling passenger trains, have, in addition to the cylinder lubricators, one which works continuously as long as the throttle is open. These are of the Roscoe system or similar to it. They are constructed on the principle of condensation of steam, and their working has been very satisfactory. The connecting and side-rods are also provided with a lubricator of the Berg-March type. The Stauffer lubricators are being tried, and their use promises to become very general.

The axle oil-boxes are lubricated in practically the same way which we have just mentioned. The engine has an air-pump and the brake has four shoes acting against the driving-wheels. Two vertical cylinders are located on either side of the engine between the axles, and they apply the brake to four wheels. The whole boiler is covered with a thin sheet-iron jacket for protection against radiation. The engine has a four-wheeled tender coupled to it by the means of a balanced system of connections which preserve the equality of the pressure on the buffers on curves. The water tank holds 7,500 litres (1,981.5 gals.) of water, and the coal space will hold 3,600 kg. (7,938 lbs.) of fuel. Some tenders, especially those used on express trains, hold 9,000 litres (2,377.8 gals.) of water.

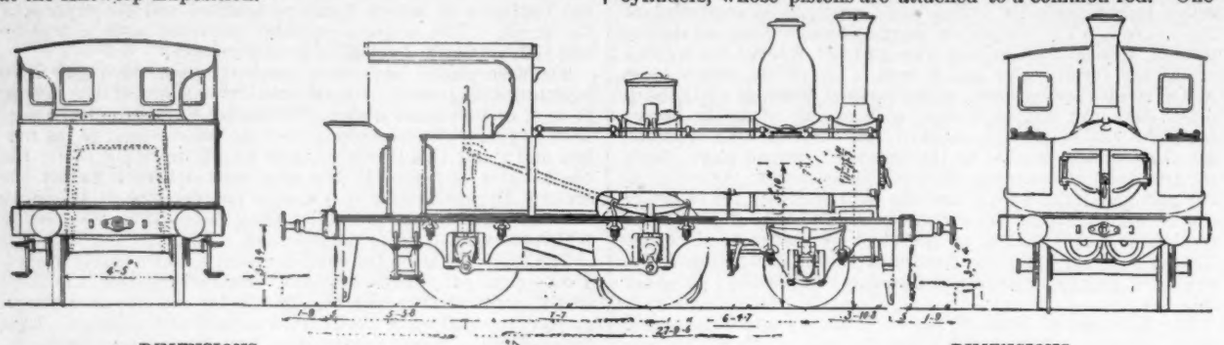
All the essential dimensions of this locomotive, as well as those whose description is to follow, are shown in the table attached. The outlines of the different types of locomotives

and tenders are also shown. Most of the arrangements which are found on this engine are also found on other types of the same administration, therefore the differences alone will be pointed out. The passenger engine with wheels 2 m. (6 ft. 6.7 in.) in diameter is very steady upon the road. It usually hauls, on level track, 15 cars having an average weight of 10 tons each, at a speed of 75 km. (46.6 miles) per hour; but as many of the express trains of the Belgian system of railroads exceed this limit of weight and speed, the management have designed a more powerful type of locomotive which still preserves a resemblance to the lines of the old machine. It is a type built by M. M. Carels, and was shown at the Antwerp Exposition.

bronze, and is provided with cheek pieces, which protect the connections. The construction of the cross-head for the piston-rod has the peculiarity that, although it is guided by four guides, it permits the forged head of the pin to be put into position without the strap being removed. This is accomplished by lowering the bracket to which the guides are attached, so as to leave the head of the wrist-pin free.

Steam is taken from the dome; the throttle-valve is, however, placed in the smoke-box against the tube sheet, where it is more easily inspected than if it were in the dome.

The ordinary reverse lever is replaced, for the purpose of trial, by a steam reversing-gear composed of two horizontal cylinders, whose pistons are attached to a common rod. One



DIMENSIONS.

Diameter of cylinders	12.6"
Stroke of pistons	18.1"
Average diameter of boiler	3' 6.4"
Number of tubes	145
Length of tubes	9' .24"
Outside diameter of tubes	1.77"
Heating surface, firebox	63.2'
" " tubes	530.9 sq. ft.

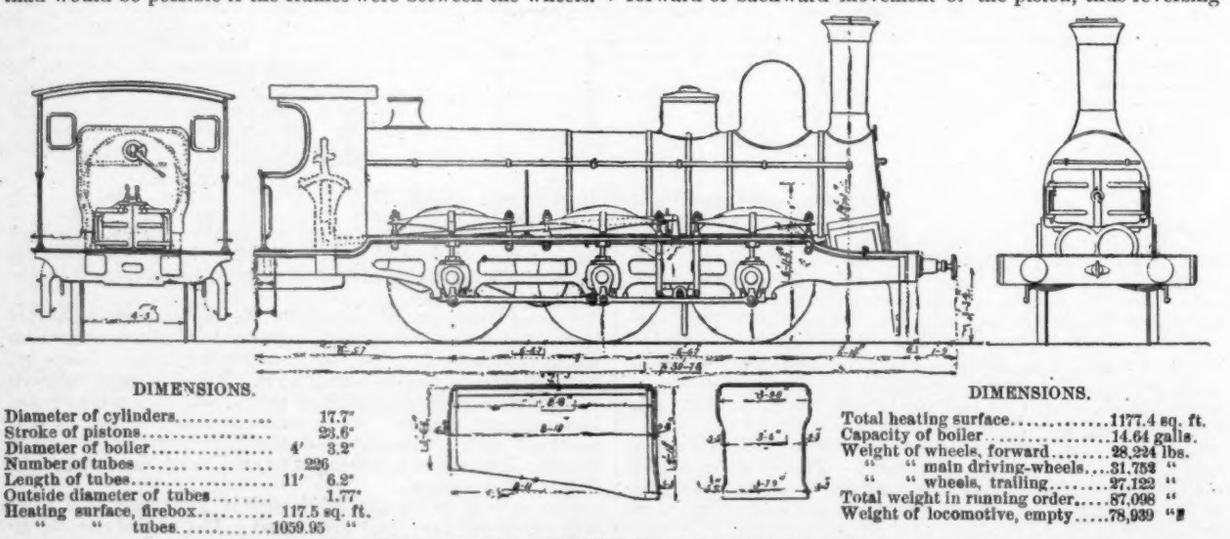
DIMENSIONS.

Capacity of boiler	747 galls.
" " water tanks	945 "
" " coal chambers	2,646 lbs.
Weight of forward wheels	21,168 "
" " main driving-wheels	25,578 "
" " trailing wheels	23,594 "
Total weight in working order	70,340 "
Weight of locomotive, empty	57,330 "

LIGHT PASSENGER ENGINE, BELGIAN STATE RAILWAYS, TYPE V.

II. *Express Locomotives with Four Wheels Coupled.*—This engine differs little from the preceding one, the fire-box has the same dimensions and construction with the exception of the length, which has been raised from 2.7 m. (8 ft. 10.29 in.) to 3 m. (9 ft. 10.1 in.). The outside frames have been maintained because they permit the fire-box to be widened out to the full distance between the tires of the wheels, thus giving an inside width of the fire-box of 6 cm. (2.36 in.) more than would be possible if the frames were between the wheels.

of these cylinders is filled with a liquid—water, oil, etc. The two ends are united by a passage which permits the piston to displace the liquid by forcing it from one end to the other. In the center of this passage there is a valve, which, when it is closed, cuts off the communication between the two sides of the piston, which is thus held in the position occupied by it at the moment when the valve was closed. The other cylinder is for steam, which is admitted by ports at the ends, causing a forward or backward movement of the piston, thus reversing



DIMENSIONS.

Diameter of cylinders	17.7"
Stroke of pistons	23.6"
Diameter of boiler	4' 3.2"
Number of tubes	226
Length of tubes	11' 6.2"
Outside diameter of tubes	1.77"
Heating surface, firebox	117.5 sq. ft.
" " tubes	1059.95 "

DIMENSIONS.

Total heating surface	1177.4 sq. ft.
Capacity of boiler	14.64 galls.
Weight of wheels, forward	28,224 lbs.
" " main driving-wheels	31,752 "
" " wheels, trailing	27,122 "
Total weight in running order	87,098 "
Weight of locomotive, empty	78,939 "

SIX-COUPLED ENGINE, BELGIAN STATE RAILWAYS, TYPE II.

Together with the outside frame there is an arrangement which has existed for a number of years on the State railroads for freight engines. There is a central frame composed of two strong sheets riveted together which receives a great portion of the reciprocating thrust of the connecting-rods. The cylinders being very near together, but a small portion of their section is carried to the outside frame. The steam distribution is on the Walschaert's system, and presents as one peculiarity the arrangement of the cross-head guide of the valve-stem in which are articulated the forward movement lever and the rod, which transmits to the said lever the movement of the valve. This cross-head is made of aluminum

the engine. By a suitable adjustment the engine-driver can locate the point of the cut-off at will. The engine is provided with a Westinghouse brake which applies eight shoes to the wheels of the coupled axles at the same time.

The cylinders have separate steam-chests provided with two covers; one is very small, which is ordinarily removed for examining the valve; the other is placed laterally, is of larger dimensions, and is removed in case the valve-seats are to be repaired. The valves are of the Allen type with double ports. The extreme wheel base is quite long, and assures the stability of the engine.

The front axle oil-boxes are furnished with guides which

allow a side play when the engine is running curves at a high speed. The contact between the plate and the top of the box is upon an inclined plane, made on two parts so that the tendency is to draw the box back into its normal position, from which it has been taken by the thrust of the rails upon the flanges of the wheels.

The springs are 1.5 m. (4 ft. 11 in.) long between the hangers. Those at the front and center are formed of 16 leaves of steel 100 × 12 mm. (3.937 × .47 in.), the back springs being composed of 17 leaves. These springs are made without any camber, and are usually convex when loaded. The first have a deflection of 16 mm. (.63 in.) per ton; the second, 17 mm. (.66 in.). The spring of the central frame has a length of 780 mm. (2 ft. 6.7 in.). It is composed of 6 leaves of steel 100 × 6 mm. (3.93 × .23 in.) with a camber of 19 mm. (.75 in.); its deflection is 21 mm. (.83 in. per ton).

The equalizing bars are attached to the outside spring of the front axle and the main driver-axle. The outside springs possess the peculiarity that their adjustment is not made with the hangers, but by a column which is called a post, and which is located between the spring band and the oil-box. All the boxes are of phosphor bronze and are solid. All friction pieces have automatic lubricators, which are easily accessible. The injectors are vertical and arranged so as to be accessible to the engine-driver while running. All the boiler attachments are inside the cab and convenient to the men. There is no piping outside the engine.

The oil-box guides are constructed in such a way that the method of attaching the lower parts have cheek pieces, so that they can be considered as one complete casting, consolidating in the most efficacious way the notch made in the frame for receiving the oil-box. The driving-wheels are 2 m. (6 ft. 6.8 in.) in diameter, and have visible counterbalances. The cylinders are inside and horizontal. The fire-box is of red copper, the tubes of brass. The boiler is made of No. 4 iron 13 mm. (.5 in.) thick for the outer case of the fire-box, and of 13.5 mm. (.53 in.) for the shell-sheets, which are subjected to flanging and are of No. 5 iron.

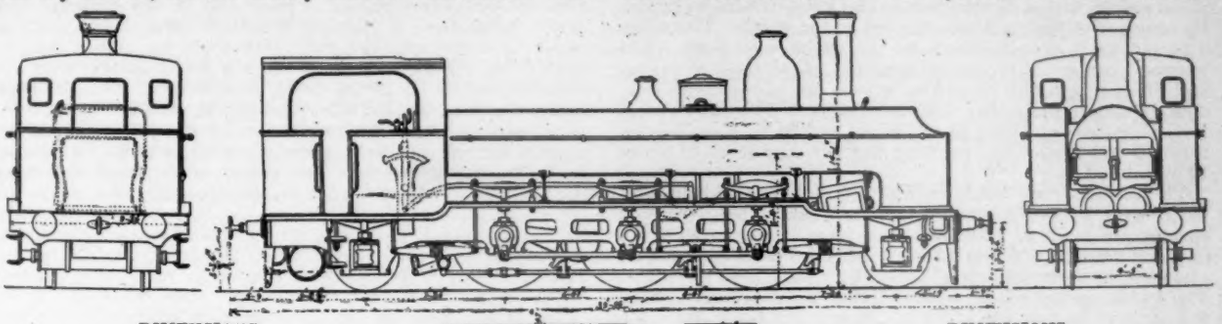
The Wilson's safety-valves are used, and they are placed over the fire-box under the control of the engineer. The sand-boxes are placed beneath the shell against the frames, and the sand is carried down in front of the main driving-wheels.

III. *Light Passenger Engine (Type 5).*—This is an engine having a tender and constructed with three frames with four coupled wheels 1.45 m. (4 ft. 9 in.) in diameter, and two-wheeled truck-axle ahead. The cylinders are inside, of small dimensions and inclined to the horizontal by 30 mm. to the meter (1.18 in. to the foot).

Walschaert's valve system is used, and, as in all similar constructions, the valve-stem is guided by the packing-box in the steam-chest and by guide supports attached to one of the cross-head guides. The reversing-gear is a hand-lever with a notched quadrant. For experimental purposes phosphor bronze has been used on a few locomotives for valve-seats, guides for the valve-stems, cross-heads, pistons and oil-boxes, phosphor bronze.

The engine is carried by 12 leaf steel springs 900 × 100 × 10 mm. (35.4 × 3.9 × .39 in.). At each end a master leaf is bent into the form of a pad upon which a bolt of the hanger rests. The connection is made by means of these hangers, and iron of the best quality is used in their manufacture, which is well filleted out at every bend. The engines have no equalizing levers nor counterweights in the driving-wheels. The box of the central frame has no springs. The great area and the heating surfaces have been proportioned to the cylinder dimensions; for a width of 1.1 m. (3 ft. 7 in.) in a square fire-box, the length is only 4.463 m. (14 ft. 6.5 in.). The outside shell of the fire-box is 12 mm. (4.7 in.) thick; the shell of the boiler is 11 mm. (4.2 in.) thick; all joints, vertical as well as horizontal, are riveted with a welt; a single line of rivets is used in the vertical rows, while the horizontal seams are double riveted. Two safety-valves are placed upon the dome, one controlled by the balance-lever, the other directly by the plate spring. The sand-box is placed upon the boiler, and as the engine is required to run both directions, two pipes lead the sand down to the front and back of the main driving-wheels.

The engine has a Westinghouse brake applying four shoes to the driving-wheels. A hand-lever with a screw is used to apply the brakes, in case the air-brake fails to work. The injectors are of a small model, but proportioned to the greatest possible consumption of water by the engine. The coal space holds 2,646 lbs. of fuel, and the tank 951.12 gallons of water.



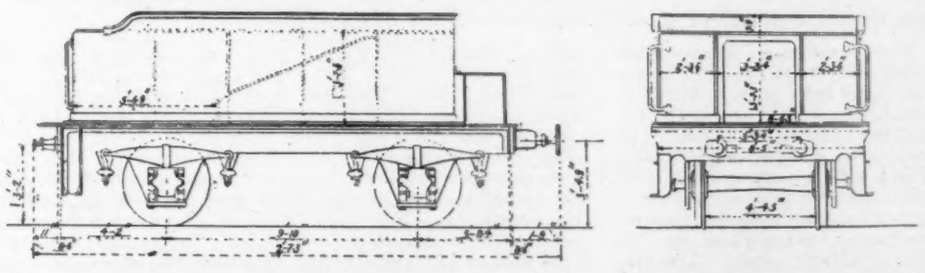
DIMENSIONS.

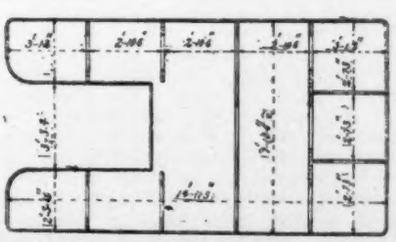
Diameter of cylinders	17.7"
Stroke of pistons	23.6"
Diameter of boiler	4' 3"
Number of tubes	226
Length of tubes	11' 6.2"
Outside diameter of tubes	1.77"
Heating surface, firebox	117.5 sq. ft.
" " tubes	1059.7 "
Total heating surface	1,177.2 "
Capacity of boiler	1,474 galls.

DIMENSIONS.

Capacity of water-boxes	2,587.6 gals.
" " coal chambers	3,750 lbs.
Weight of front pair of wheels	22,270 "
" " second pair of wheels	28.665 "
" " third " " "	30,860 "
" " fourth " " "	27,540 "
" " fifth " " "	23,373 "
Total weight in working order	132,708 "
Weight of locomotive, empty	94,815 "

TEN-WHEELED PASSENGER ENGINE, BELGIAN STATE RAILWAYS, TYPE IV.





TENDER FOR HEAVY PASSENGER ENGINES, BELGIAN STATE RAILWAYS.

DIMENSIONS.

Capacity of tank	2,378 galls.
" " coal chambers	7,938 lbs.
Weight of forward wheels	27,563 "
" " rear "	23,373 "
Total weight in running order	50,936 "
Weight of tender, empty	23,173 "

IV. *Engines with Six Wheels Coupled, of 1.7 m. (5 ft. 6.9 in.) Diameter (Type 2).*—The whole weight is here utilized for adhesion. The frames are composed of three pieces, one being central, and the other two outside the wheels; the cylinders are inside and inclined one-ninth, and have separate steam-chests. The engines built before 1882 have a single steam-chest cover, the more recent ones have two, one of which is very small and is placed in front, so that the valve may be readily inspected; the second is rendered indispensable by the steam-chest being cast in one piece.

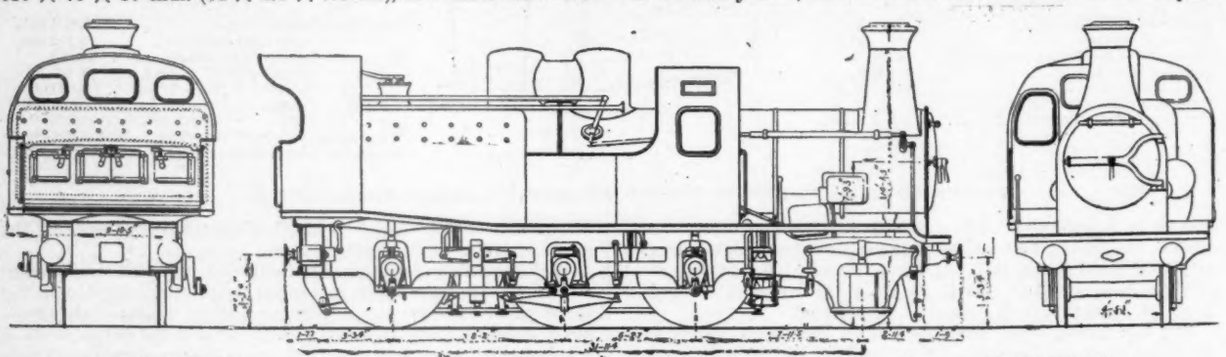
The valves are of bronze, many engines being provided with Allen valves with a double port. The valve is held to its seat by means of a plate spring attached to the chest. The steam distribution is accomplished by the Stephenson link. The journal-boxes are of bronze composed of 84 per cent. of copper and 16 per cent. of tin. The wheels are of wrought iron, spoked and without any counterbalance. The tires are of Bessemer steel attached to the wheel center by bolts passing through the center and entering the tire to a depth of about 19 mm. (.75 in.).

The oil-boxes are made entirely of cast iron and are provided with wedges for taking up the wear. The suspension springs are made of 13 leaves, each 10 × 100 mm. (.39 × 3.9 in.), and measure 900 mm. (2 ft. 11.4 in.) from center to center of hangers, their deflection being 8.4 mm. (.3 in.) per ton. The inside spring of the central frame has four leaves, each 610 × 75 × 10 mm. (24 × 2.9 × .39 in.), and has a deflection of 12 mm. (.87 in.) per ton. These springs are not provided with any equalizing lever. Lately reverse springs of 22 leaves of 10 × 100 mm. (.39 × 3.93 in.) steel have been substituted. They are made without any camber, and are 1½ m. (4 ft. 10.4 in.) long; their deflection is 22 mm. (.86 in.) per ton. The inside spring has been made with some modification; it has a length of 660 mm. (2 ft. 1.9 in.) with a camber of 30 mm. (1.18 in.) and a deflection of 21 mm. (.82 in.) per ton. It is composed of five leaves 100 × 8 mm. (3.93 × .31 in.) in size. The long springs outside of the main driving-wheel and the trailers have been provided with equalizing levers. The fire-box is absolutely similar, both in dimensions and the method of its construction, to those of the passenger locomotives with wheels 2 m. (6 ft. 6.7 in.) in diameter. It is made of red copper throughout. The side sheets, the front tube-sheet and the crown are 12 mm. (.47 in.) thick; engines of recent construction, where the pressure has been increased (type 29), have sheets 14 mm. (.55 in.) thick. The tube-sheet is also of copper, and is 29 mm. (1.14 in.) thick where the tubes are set and 14 mm. (.55 in.) below them.

The cylindrical portion of the boiler and the outer shell of the fire-box are made of No. 4 iron, with the exception of those sheets which have to be flanged, for which No. 5 iron is used. These sheets offer a minimum resistance to a tensile pull of 72,770 lbs. per square inch in the direction of the fiber, and 61,740 lbs. at right angles, with a minimum corresponding elongation of 9 per cent. and 5 per cent. The specification for the copper sheets of the fire-box require that they shall carry before rupture a minimum load of 48,500 lbs. per square inch, and that they have an elongation of at least 22 per cent. of their original length. The assemblage of the sheets offers nothing practically novel, as it is identical with that which we have described in connection with the passenger locomotives with 2 m. (6 ft. 6.7 in.) drivers (type 1). None of the other details or accessories are varied at all. It may be noted, nevertheless, that the Wilson safety-valve has been recently adopted and been placed over the fire-box. As in all passenger locomotives of type 2, these engines also have a Westinghouse brake operating six brake shoes upon the six driving-wheels. This engine is used to haul passenger trains upon grades, and easily takes the load of 80 tons up a continuous grade of 1.6 per cent. at a speed of 34.17 miles per hour.

V. *Ten-Wheeled Passenger Locomotives with Tender (Type 4).*—This type only differs from the preceding by an addition of water tanks and coal-boxes. This supplementary load is carried by two axles placed at each end of the engine. The water tanks have a capacity of 10,000 litres (2,642 gals.) of water, and the coal-box can carry 3,000 kg. (6,615 lbs.) of coal. The outside axle-boxes have a radial motion with cylindrical guides; a spring being used to bring the axles back to their normal position when the engine passes from a curve to a tangent. It is by the pressure of the flange of the tire against the rail that the reverse is accomplished. Equalizing levers are used to connect the springs of the truck-axle with the back driver, the front truck springs being also connected by equalizing levers. The effect has been not only to lessen the variation of loads which are inevitably produced with engines of a long wheel base, but to assure a certain safety of running when the axles have a chance for radial adjustments.

VI. *Express Locomotives for Heavy Grades (Type 6).*—As we have already said, the locomotives with six wheels coupled



DIMENSIONS.

Diameter of cylinders	19.7"
Stroke of pistons	23.6"
Diameter of boiler	4' 7.1"
Number of tubes	240
Length of tubes	13' 15"
Outside diameter of tubes	2"
Heating surface, firebox	171.5 sq. ft.
" " tubes	1507 "

DIMENSIONS.

Total heating surface	1,678.5 sq. ft.
Capacity of boiler	2,246 galls.
Weight first pair driv.-wheels	27,562 lbs.
" second pair driv.-wh'l	30,870 "
" third " "	31,973'
" fourth " "	30,910'
Total weight in running order	121,315'
Weight of locomotive, empty	121,475 lbs.

EXPRESS ENGINE FOR HEAVY GRADES, BELGIAN STATE RAILWAYS, TYPE VI.

with a diameter of 1.7 m. (5 ft. 6.9 in.) can draw upon the long grades of 1.6 per cent from Luxembourg 80 tons at a speed of 34.17 miles per hour. Some express trains, however, which travel over this line frequently have a normal load of 110 tons, and are compelled to maintain a velocity of 40.38 miles upon heavy grades. The management of the State railways therefore ordered a locomotive with six wheels coupled for the service of these fast trains from Cockerill at Seraing. The wheels are 1.7 m. (5 ft. 6.9 in.) in diameter with a radial truck. The principal characteristic of the engine lies in the large dimensions given to the cylinders, the grate area, the heating surfaces and the smoke-box. The cylinders have a diameter of 50 cm. (19.68 in.), a stroke of 60 cm. (23.62 in.), are between the frames and are located between the truck axle and the forward driving-axles. The engine has three frames, the wheels being inside the outer one. The Walschaert valve-motion is used. A steam reversing-gear similar to the one described in connection with the four wheels coupled engine is used. The suspension springs are inverted, their length is 1½ m. (4 ft. 11 in.); equalizing levers are used between the springs of the front and back axles. The grate is 22 m. (6 ft. .17 in.) long by 28 m. (7 ft. 7.8 in.) wide; it therefore extends over the rear drivers. The fire-box is of copper, and is provided with a combustion chamber whose heating surface is .9 of a square meter (9.68 sq. ft.). It is connected with the cylindrical portion of the boiler by two horizontal tubes. The steam space of the fire-box and of the shell are connected through the domes. The fire-box has four doors. The shell has a diameter of 1.4 m. (4 ft. 7.1 in.). The tubes are of iron 2½ mm. (.1 in.) thick. The stack is rectangular.

The engine-driver is not located, as in other engines, at the rear end of the machine, since the special form given to the fire-box renders it impossible to see the signals from this point, and he is placed in a cab on the right-hand side at the junction

of the shell and the fire-box, communication with the fireman being maintained through a speaking-tube. Water-glass and a steam-gauge are at hand by which he keeps track of and can control the fire. This engine has a Westinghouse brake, applying shoes to the six driving-wheels. A tender with a capacity of 14,000 litres (1,321 gals.) is used.

PROGRESS IN FLYING MACHINES.

By O. Chanute, C.E.

(*Continued from page 246.*)

Ascending trends of wind are by no means rare, as abundantly proved by published observations since M. *Pénaud* called attention to the many causes which must produce such trends. This was shown in a very able paper on "Sailing Flight," which was published in part in the *Aéronaute* for March and April, 1875, but which, unfortunately, was left unfinished. M. *Pénaud* demonstrated that such winds must necessarily result from even moderate undulations of the ground (and therefore *a fortiori* from mountains or deep valleys), from natural or artificial objects acting as wind breaks, from the meeting of air currents flowing in different directions, or even from the heating effect of the sun. He doubtless expected to show, in the portion of the paper remaining unpublished, that an upward trend of $\frac{1}{9}$ to $\frac{1}{6}$ (from 6° to 10°) in the wind was quite sufficient to enable a sailing bird to progress against the breeze by inclining his aeroplane so that the horizontal component of the pressure would have a forward direction, while the wind still acted on the under side; for we have already seen in computing the foot pounds expended by a 1 lb. pigeon in gliding, that with a speed of 40 miles per hour and an angle of incidence of 3° the "drift" will be 0.05647 lbs., while the body resistance and that of the edges of the wings together will be 0.05555 lbs., and that at 5° (30 miles per hour) the "drift" will be 0.08892 lbs., and the resistance of the body and edge of wings will be 0.03124 lbs., so that in both these cases the "drift" (calculated even with the coefficients which have been obtained with planes, and which are known to be inferior to those to be expected from concavo-convex surfaces) is sufficient, if directed forward, to overcome the resistances and to give to the sailing bird a forward impulse; this reversal in direction of the "drift," as previously explained, occurring when the plane becomes inclined so as to point forward below the horizon.

Since *Pénaud's* day a great many observations have confirmed the frequent prevalence of both ascending and descending currents. Aeronauts, more particularly, have noted that the atmospheric currents follow the undulations of the ground, causing their balloons to subside upon approaching a valley, or to rise when nearing a cliff or a mountain. They have also inferred, from the fact that they have found butterflies a mile or more above the earth while sailing over table lands, that these trends are frequent in such regions, although their effect upon the balloon is less immediately noticeable than in mountainous countries, where the angle of ascent often is 45° or more. In such broken countries very curious observations have been made as to the invariable prevalence of steeply ascending winds in certain well-defined localities when the wind blows from a particular quarter; such, for instance, as the observations of M. *Mouillard* in the Lybian chain near Cairo, and those of M. *Bretonniere* in the vicinity of Constantine, Algeria, where certain zones or gaps of ascending winds seem to exist, which the sailing birds utilize to gain elevation by circling. There they congregate in crowds, forsaking the rest of the sky, and spirally mount on rigid wings, until they have gained sufficient altitude to carry them toward any point which they may want to reach in descending.

It is probably in sub-tropical regions that such phenomena are most numerous and permanent; but the reader, who is accustomed to thinking of the wind as blowing horizontally, may be quickly edified by watching the smoke issuing from a tall chimney even in northerly climates. This smoke will be seen at various hours, or on various days, to trend either upward or downward or with exact horizontality, as may depend upon the undulations of the great atmospheric waves which are produced by the impinging upon each other of the currents flowing and crossing at various altitudes; or if the observer have the good fortune to be in the regions inhabited by the sailing birds, he may satisfy himself as to the similar atmospheric undulations which are constantly taking place, even in a perfectly flat country, such as the plains of Texas or the sea beaches of Florida, by liberating bits of down or threads of smoke from the same spot at various times or days. He will also observe the local ascending currents permanently produced by a mere wind break, such as a belt of trees facing the inflowing sea breeze. He may satisfy himself (by attaching light strips of bunting or bright-colored threads to the tops of those trees) that the breeze is deflected upward just over their upper branches, and he will then understand why these spots constitute the favorite haunts of the sailing birds when the breeze is light. He will see the soarers for hours gliding back and forth and back and forth on pulseless wings, just above the top of the wind break formed by these belts of trees, evidently utilizing the ascending current to patrol the adjoining beach while awaiting, with no labor, whatever food may be brought by the incoming tide, or an opportunity of eating it undisturbed.

It is not intended here to convey the impression that ascending trends of wind are absolutely necessary for sailing flight. The writer has seen the feat performed many times, when every test seemed to prove that the current was absolutely horizontal; but it then seemed to him that on such occasions the equilibrium was more difficult to maintain, and that the bird had to bestow greater attention upon the nice adjustments required to preserve his balance and to produce "aspiration" when the wind varied in intensity and direction; just as an acrobat experiences greater fatigue in walking a tight rope, through the attention and care expended to avoid falling, than in walking many times the same distance on the ground, where no particular care is required to preserve the balance. It is probably because of such relief from all cerebral strain that the soaring birds seem to sail with less care and with far greater steadiness whenever they are utilizing an ascending current. They are then easily and safely sustained, and so mechanical does the performance seem that some observers have expressed the opinion

Fig. 69.—SIMPLEST CHINESE KITE.

that they then sleep on the wing. There is no doubt, moreover, that ascending trends of wind enable the creatures to soar in lighter breezes than would otherwise be possible, and when the faint morning wind first begins to blow, many of the sailing birds will be seen congregated just above wind breaks, while the other parts of the sky are vacant.

But to return from this digression, occasioned by the feat of "aspiration" performed by M. *Myers'* kites, it will be discerned that the principle of flexibility alluded to confers stability upon the well-known *Japanese kite*, specimens of which are now to be found in almost all toy shops. This kite flies without a tail, the frame being so light and elastic that the surface adjusts itself constantly to the irregularities of the breeze. The side pockets catch the wind, and by springing back of the medial line form a diedral angle which confers lateral balance, while the flexibility up and down confers longitudinal equilibrium. The same principle is exemplified in the upward bending of the extremities of the feathers of birds in flight, which doubtless adds much to their stability, and, indeed, so universally is this principle illustrated by all creatures which navigate fluids, that Dr. *Amans*, in a work upon the locomotive organs of fishes,* lays it down as an axiom derived from physiological consid-

* Comparaison des organes de la locomotion aquatique, P. C. Amans.

erations, that an aeroplane of rigid form is *contre nature*, or in direct antagonism with all the inferences to be drawn from the observation of creation.

The Japanese are expert kite flyers, and have produced many shapes besides that which has been above alluded to. They are said to use kites as weather vanes, and to have hitching posts in their gardens to which the device is almost permanently affixed. Indeed, it is said that these kites sometimes remain 8 or 10 consecutive days up in the air—an astonishing achievement to European and American kite

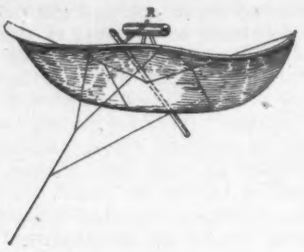


FIG. 70.—CHINESE MUSICAL KITE.

fanciers, who seldom succeed in keeping their apparatus up more than a few hours. The explanation is probably to be found in the greater regularity and permanence of the air currents in the regions of trade winds, and these too are the regions where the soaring birds are most numerously found, probably because they are there sure of a sustaining breeze every day, through the use of which they may evade the fatigue of flapping flight.

The various forms of the *Chinese kites* are even more numerous than those of the Japanese, and most of the tailless kind, are said to depend upon the same principle of flexibility for their equilibrium. It would not at all be surprising to find, should a stable aeroplane be hereafter produced, that it has its prototype in a Chinese kite; but the writer has discovered very little information in print upon the subject; the following article, translated from *La Nature* by the *Scientific American* and published in its issue of March 24th, 1888, being perhaps the best available:

One of our correspondents in China, Mr. Huchet, at present in Paris, has had the kindness to have made for our purposes, by a skillful Chinese manufacturer, a series of models representing the different types of kites used everywhere in China, Annam, and Tonkin, and which the same gentleman has been obliging enough to bring to us in person.

Fig. 69 represents the simplest form of these kites. Its frame is formed solely of a stiff bamboo stick, *A B*, and two slightly curved side rods, *C D* and *E F*. To this frame is pasted a sheet of paper, which is somewhat loose at the extremities *C E* and *D F*, where, under the action of the wind, pockets are formed that keep the affair bellied and in an excellent position of equilibrium. Our engraving shows the mode of attaching

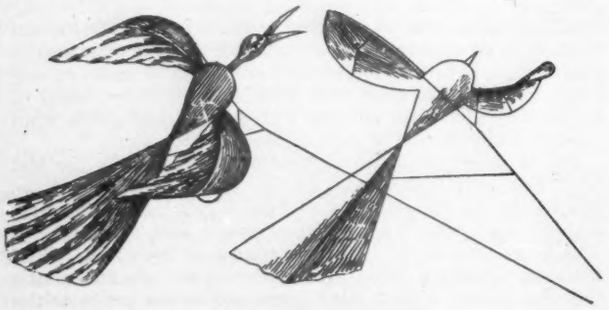


FIG. 71.—CHINESE BIRD KITE.

the strings that serve to hold it. Kites of this kind are usually about three feet in width.

Fig. 70 shows the appearance of the musical kite, so called because it is provided with a bamboo resonator, *R*, containing three apertures, one in the center and one at each extremity. When the kite is flying, the air, in rushing into the resonator, produces a somewhat intense and plaintive sound, which can be heard at a great distance. This kite is somewhat like the preceding, but the transverse rods of its frame are connected at the extremities and give the kite the aspect of two birds' wings affixed to a central axis. This kite sometimes reaches large dimensions—say 10 ft. in width. There are often three or four resonators placed one above another over the kite, and in this case a very pronounced grave sound is produced. Mr. Huchet informs us that the musical kite is very common in China and Tonkin. Hundreds of them are sometimes seen hovering in the air in the vicinity of Hanoi. This kite is the object of certain superstitious beliefs, and is thought to charm evil spirits away. To this effect it is often, during the prevalence of winds, tied to the roofs of houses, where, during the whole night, it emits plaintive murmurs after the manner of Æolian harps.

Among ingenious fancies of the Chinese is their bird kite, fig. 71, the frame of which is made elastic. The thin paper attached to the wings moves under the action of the wind and simulates the flapping of the wings. This kite is sometimes 3 ft. in length.

The most curious style of Chinese kites is the dragon kite, fig. 72. It consists of a series of small elliptic, very light disks formed of a bamboo frame covered with India paper. These disks are connected by two cords which keep them equidistant. A transverse bamboo rod is fixed in the long axis of the ellipse, and extends a little beyond each disk. To each extremity of this is fixed a sprig of grass which forms a balancing plume on each side. The surface of the foremost disk is slightly convex, and a fantastic face is drawn upon it, having two eyes made of small mirrors. The disks gradually decrease in size from head to tail, and are inclined about 45° in the wind. As a whole, they assume an undulatory form, and give the kite the appearance of a crawling serpent. The rear disk is provided with two little streamers that form the tail of the kite. It requires great skill to raise this device.

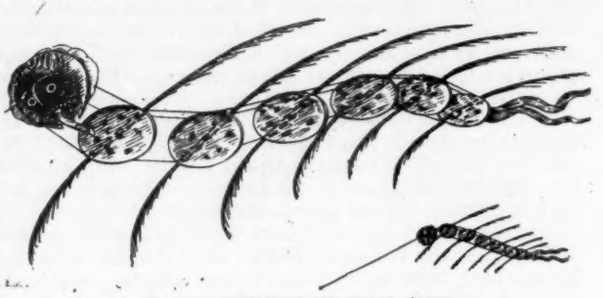


FIG. 72.—CHINESE DRAGON KITE.

This last device resembles in arrangement the multiple disk kites for life saving of the Rev. Mr. *Corder*, already described, and suggests that the superposition of kites affords a good field for experiment. There is a limit in size beyond which the increasing leverage will so add to the required strength and weight of the frame as to make a kite unduly heavy as well as unwieldy,* and superposition naturally suggests itself for experiments intended to test the efficacy and equilibrium of kite aeroplanes. There will be many practical details to work out in devising the best mode of attachment of such aeroplanes with each other, so that all surfaces may pull together and yet counteract the effects of wind gusts, so that experiments with kites seem to offer the readiest, quickest, and least expensive method of working out this part of the problem.

The attention of experimenters is specially called to the form of kite shown in fig. 70. It resembles in shape and attitude those of the soaring birds, which, as already remarked, perform their manœuvres with peculiarly curved and warped surfaces, and it will be seen hereafter that the nearest success in compassing gliding flight hitherto obtained—that of M. *Lilienthal*—has been achieved with just such surfaces.

Inventors seem to have bestowed but little attention upon kites, less than a score of such devices having thus far been patented in the United States. These patents chiefly cover various methods of making the frames to fold, so that the kite may be more portable, while but few inventors seem to have considered how the stability may be increased. Among these latter may be mentioned Mr. *Clarke* (No. 96,550), who proposes the insertion of a spring on one of the three cords which compose the bridle. By the yielding of this spring

* The largest kite on record is said to belong to a Japanese gentleman, and is 50 ft. × 45 ft., weighing 1,700 lbs. Its frame is composed of 350 pieces of wood.

the angle of incidence of the kite may vary somewhat with the varying velocities of the wind, and thus diminish the perturbations.

Mr. *Maddans* (No. 121,056) proposes a kite with a convex surface, this being obtained by providing a stick across the top, which stick is sprung into a bow by attaching its ends to each other; but this bowing seems to have been chiefly devised to attach a flapping tongue, rotating on the bow-string and so making a drumming noise, while there is no doubt that the convexity of the kite must add to its stability.

Mr. *Thompson* (No. 225,306) patents a reversible convex or concave kite, with a frame like that of an umbrella; but nothing is said of the equilibrium or of dispensing with a tail, the object being, apparently, to provide for convenience in carrying.

Mr. *Colby* (No. 354,098) provides for the stability by inserting in the middle surface of a kite a wind bag rearwardly projecting, which is distended by the breeze and prevents the kite from darting. This is virtually the same device as that of Mr. *Copie*, already mentioned, which was found to require a central opening to allow the escape of the air when experimented in large dimensions. It is evident that such a device, if applied to a navigable aeroplane, would largely increase the resistance to forward motion; but this might be minimized by making such wind pockets very shallow, and inserting a large number in the aeroplane. The experiment may be worth trying by kite fanciers.

While several forms of folding frames for kites have been patented by inventors, few seem to have been designed to act as parachutes also. This has been accomplished recently by Mr. *Moy* in a very simple way (British patent No. 1,916, A.D. 1892) by providing the folding frame with a central hub, to which a trapeze bar may be suspended when such a kite is used for conveying passengers or for exploration. By using two lines, the angle of incidence may be controlled, and the kite be made either to raise a weight or to descend slowly to the ground as a parachute.

As already intimated, the writer has found singularly little on record concerning kites, and that little bears but slightly upon the important question of the stability of aeroplanes. It may be for lack of more thorough search that only fragmentary information has been gathered. Kites are supposed to have been invented 400 years before the Christian era by Archytas, a resident of Smyrna (where the flying of kites remains a national sport to this day), and the Asiatics have always been and are now the great kite experts of the world. It is, therefore, not improbable that search in books of travel or inquiries addressed to Orientals might elicit information bearing directly upon the flying machine problem; and it is much to be desired that some competent person shall undertake to write a critical account of kite experiments as well as of the kites of all nations, and of the influence of form as to stability and sustaining power. There is a large collection of Chinese kites in the National Museum at Washington, and it would certainly be interesting to have an account of the various principles exemplified and of the behavior of the various shapes in the air.

(TO BE CONTINUED.)

FOUR-CYLINDER COMPOUND EXPRESS PASSENGER LOCOMOTIVE FOR THE PARIS, LYONS & MEDITERRANEAN RAILWAY.

On p. 499 of our issue for November, 1892, we gave a perspective view of a four-cylinder express passenger compound locomotive built for the Paris, Lyons & Mediterranean Railroad. During 1892 three of these engines were put in service.

These new locomotives, like those built in 1888, are equipped with the Serve tube and steel boilers built for a working pressure of 200 lbs. per square inch; but the use of steel has been pushed still further, and used for the fire-boxes, while in 1888 copper was still used for that purpose.

As in the 1888 type, the cylinders are four in number, the difference being that the high-pressure cylinders, instead of being inside are outside the frames, while the low-pressure cylinders are inside. The two first drive the trailing-wheels and the two latter the forward drivers, the two pair being coupled together, as in the 1888 type; but whereas in 1888 both pair were placed ahead of the fire-box and between two pairs of truck-axles, in the new type they have been pushed back to the rear end of the engine, and the forward end carried by a single pony truck or a four-wheeled bogie.

The valve-motion is of the Walschaert system for the high-pressure cylinders, that of the low-pressure being of a special system without eccentrics, which had already been used for the inside cylinders of the 1888 locomotives.

Reversing is accomplished by means of a steam reversing-gear controlling the valve mechanism of the four cylinders, and fixing, for each point of cut-off, a ratio independently of the engine-driver and properly established in advance.

Finally, the new engines are arranged like those of 1888, so as to permit the direct admission of steam from the boiler into the intermediate receivers between the large and small cylinders. This can be done at starting only and without permitting the exhaust from the small cylinders to escape into the air.

The three new engines are identical with one another, except that two are carried by a bogie ahead, while the third has a single pony truck with a lateral play of $\frac{1}{2}$ in. governed by inclined planes of 1 in 10.

The distinctive characteristic of the two engines is their relative lightness. In fact, while the engines of Classes 1 and 2 of 1888 weighed in working order about 53.5 tons, the new engines with bogie trucks, Classes 11 and 12, do not weigh more than 47.9 tons, and those without bogies 45 tons, yet the new engines are considerably more powerful than the old.

But in order to understand the superiority in the power of the new engines, and how they can be made so much lighter, it is necessary to examine into the experiments made in the shops of the Company with the Serve tubes, which formed the starting point for the construction of the new type.

Reference has already been made in these columns (see RAILROAD AND ENGINEERING JOURNAL, pp. 379 and 549, Volume LXV.) to the economy obtained by the use of the Serve tubes. Similar tests made at the Paris, Lyons & Mediterranean shops show an increase of efficiency of 21 per cent.

The reduction in the weight of the engines is not entirely due to the use of the Serve tubes, but is partially the result of the use of steel fire boxes, by which a little more than a ton is saved in the weight of the engine.

Especial attention may well be directed to the conditions governing the designing of the boilers of the new machines, because this is the point in which they differ from those that have preceded it. The second point in which they differ is the location of the axles, relatively to the principal weight of the engine, and especially to the position of the cylinders. The rear axle is still beneath the fire-box, but further back than before. At the front the cylinders are not ahead of the first axle, but the two inside cylinders are exactly in line with the center line of the bogie or over the pony truck; the other two are drawn back toward the center of the machine. The result is a great amelioration of the lateral shocks which the forward pair of wheels or the bogie deliver to the track, when the inequalities of the latter throw the engine to one side, and also a great reduction of the moment which tends to raise the front end of the engines and which is due to the obliquity of the connecting-rods.

The engine rests upon the bogie through the spherical center plate only, so that the load is equally divided between the two rails and the two axles. As each axle is provided with its own springs, it is enough to regulate the suspension links to so arrange it that the four wheels carry an equal load.

The socket of the center plate is not fixed relatively to the bogie. It can turn about its own vertical axis, and as it rests upon a helicoidal surface ascending to the right and left, it rises along these surfaces each time that it turns. Now, this socket turns around its vertical axis at the same time as the pivot, which it draws by means of two fingers provided with rollers, and arranged so as not to hinder the other relative movements of the pivot and the socket. The result is that every angular displacement of the bogie relatively to the engine on the horizontal plan causes a slight elevation of the forward end, so that as soon as the cause of this angular displacement is removed, the weight of the engine draws the truck back into line. This is not, however, the only motion that the socket can make relatively to the bogie. It is susceptible of a side motion on its seat of $\frac{1}{2}$ in. on each side of its central position. In order to regulate this displacement, the seat in question rests upon a second lower and immovable seat, with surfaces inclined about 15 per cent. The engines having a single pony truck permit a lateral displacement of the latter on each side of the central position of $\frac{1}{2}$ in. with inclined planes of 10 per cent. inclination.

The engines were built upon the compound system, because experience has confirmed the economical results which we would naturally expect when combined with a pressure of 200 lbs. per square inch. Four cylinders have been used, because the experiments made in 1888 have shown that the unavoidable complications resulting from a double mechanism was

Fig. 1

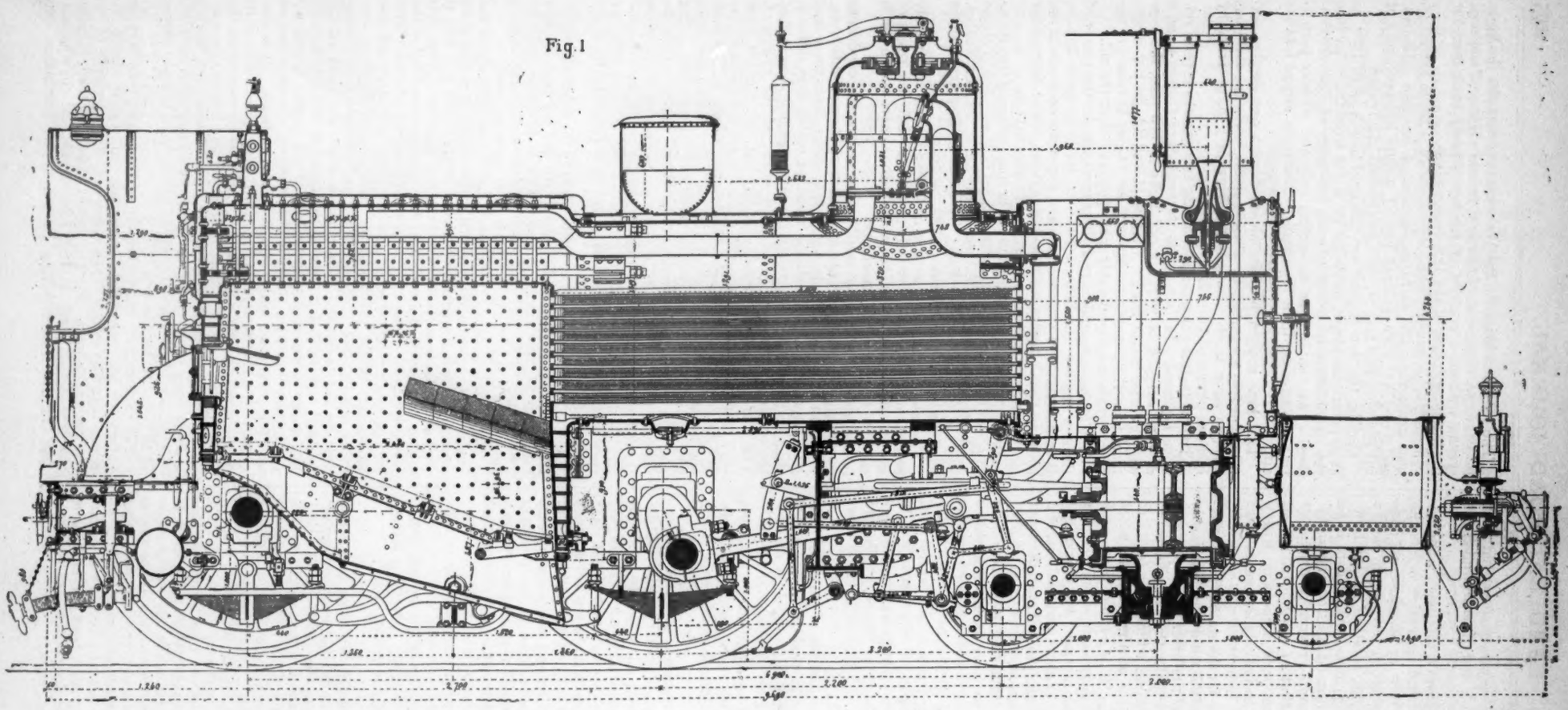
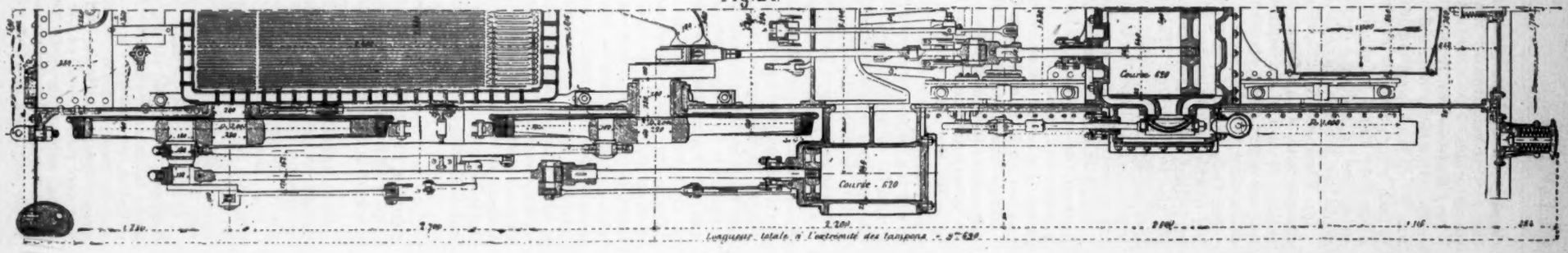
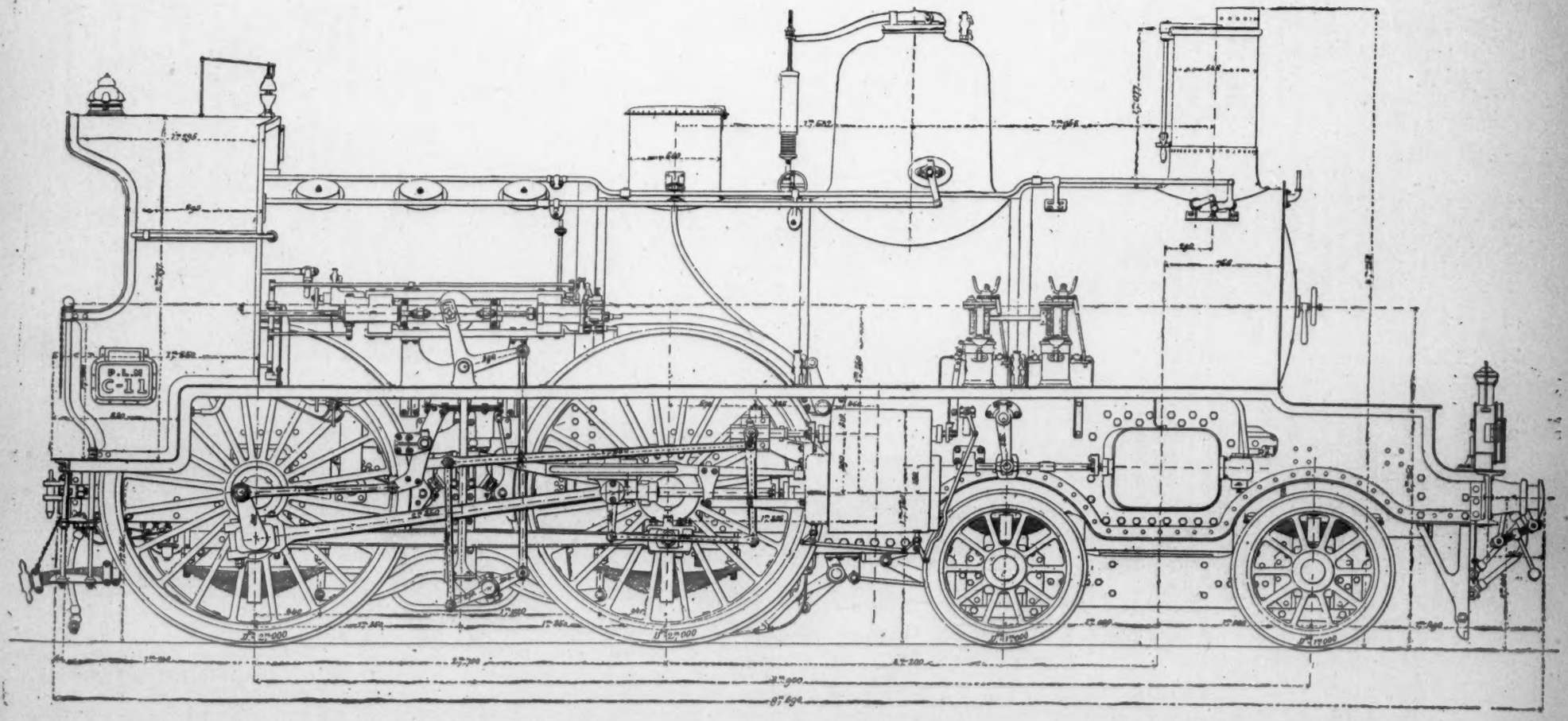


Fig. 2



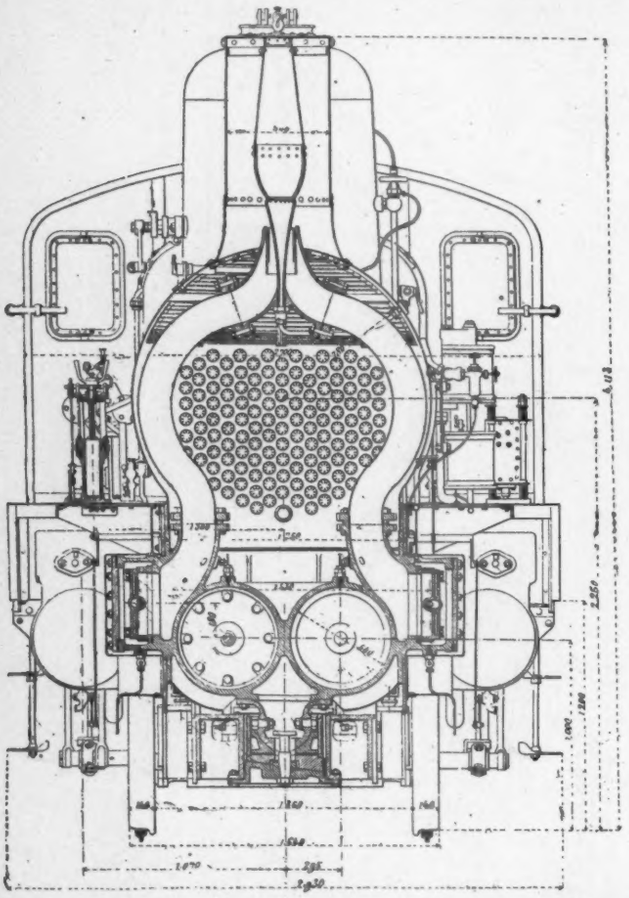
LONGITUDINAL, VERTICAL, AND HORIZONTAL SECTIONS OF FOUR-CYLINDER EXPRESS PASSENGER LOCOMOTIVE, PARIS, LYONS & MEDITERRANEAN RAILWAY.



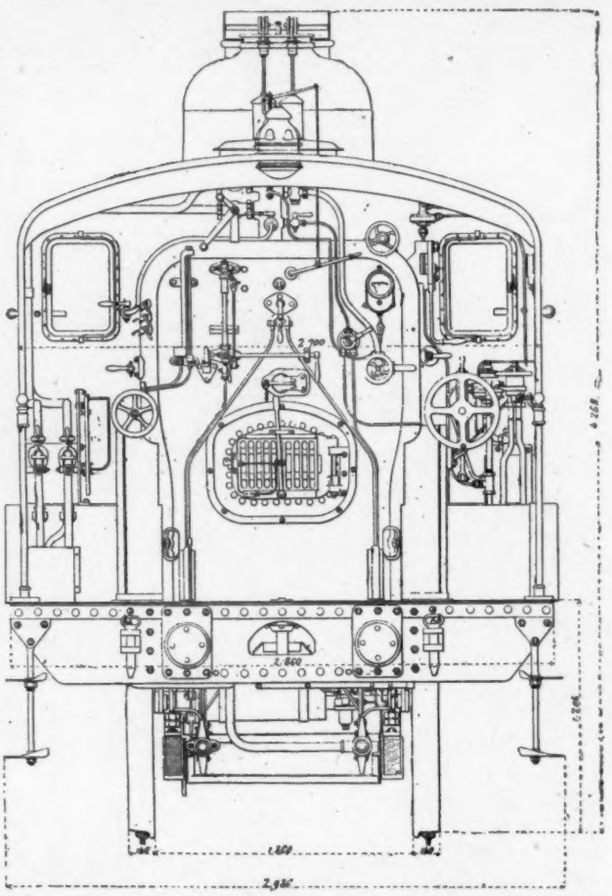
SIDE ELEVATION OF FOUR-CYLINDER EXPRESS PASSENGER LOCOMOTIVE, PARIS, LYONS & MEDITERRANEAN RAILWAY.

perfectly admissible in practice, and because this division of the motive power between two engines, each working on a separate axle, possessed great advantages in reducing the strains on the different portions of the mechanism, upon the axles, and upon the track, and finally, by reducing the disturbances due to inertia. In reference to the overload upon each wheel, the use of four cylinders allows this to be reduced to 3,000 lbs. for the front pair of driving-wheels and 3,250 lbs. for the rear pair of driving-wheels at a speed of 43.5 miles per hour; while, at the same speed with two-cylinder engines, the overload is 9,500 lbs., although the power is 20 per cent. less.

Although each driving-axle is driven direct by two of the cylinders, they have been coupled together in order that the relative angularity of their cranks might remain unchanged, and in addition to this coupling this relative angularity of their cranks has been so arranged that the starting power shall be as great as possible. The cranks of the low-pressure cylinders are therefore 135° in advance of the high-pressure. This is not the best angle when viewed from the standpoint of swaying and heaving; but even in this respect it makes the



CROSS-SECTION THROUGH CENTER OF LOW-PRESSURE CYLINDERS.



REAR ELEVATION.

compound better than the two cylinder engines, even though the latter may be less powerful, as the following table shows:

	Simple Engines.	Compound Engines.
SIDE SWAY.		
Maximum of the moment producing the side swaying at a speed of 62 miles per hour	51,160 foot-lbs.	41,201 foot-lbs.
Amount of side sway independently of the speed at the front axle or the center pin of the truck	.055"	0512"
VERTICAL HEAVING.		
Maximum of the effort producing vertical heaving at a speed of 62 miles per hour.	516,650 lbs.	13,570 lbs.
Amount of heaving, independent of the speed	.15"	13".

The ratio of the volumes of the small to the large cylinders is as 0.40 to 1; and the steam distribution of the two groups of cylinders is so joined as to equalize as much as possible, for every point of cut-off, the diagrams of the small and large cylinders.

The reversing-gear is so combined as to maintain the desired relationship between the two distributions, by means of two conveniently located cams, whose shaft has a horizontal motion parallel to the center line of the engine, and this motion gives it a simultaneous rotation by means of toothed sectors which are keyed to the cams and mesh in with a fixed rack. The movement of the cam-shaft is accomplished by means of a nut fastened to that shaft and a screw operated by the engine-driver. The operating wheel is furthermore arranged, according to the type adopted by the Paris, Lyons & Mediterranean in 1880, so as to act upon the reversing-screw only after it has opened in the proper direction the single admission valve for steam for the two cylinders, each one of which controls one of the lifting arms. These two cylinders are placed ahead of the cams. Two other cylinders placed behind them are filled with oil and serve to keep the lifting arms immovable while the engine is running; for this reason the single valve, through which communication between the front and back ends of these cylinders is obtained, is normally closed; it is opened, however, at the same time as the steam-valve and by the same motion of the hand-wheel by the driver, the reverse motion closing it. Arrangements are made for filling these cylinders and keeping them perfectly full in spite of leakages.

These new machines have a special steam-valve by means of which the engineman can admit live steam direct into the receiver between the large and small cylinders; there is also a safety-valve on this receiver which opens into the atmosphere and prevents the pressure from rising above 85 lbs. per square inch. The engineman should so handle this valve that he avoids, as far as possible, the opening of the safety-valve. The size of the cock and the pipe which leads from it to the receiver are so proportioned to the size of the safety-valve that the latter is sufficiently large to keep the pressure down to the required limits at all times. With this arrangement, in connection with the coupling of the driving-axles, the starting is accomplished at all times without any difficulty.

The stack is of large diameter, but is contracted on the in-

side in accordance with the standard adopted by the Paris, Lyons & Mediterranean in 1888, by a central node placed above the exhaust, and made so as to properly expand the jet of steam.

The exhaust is of rectangular section, and can be varied by means of movable valves.

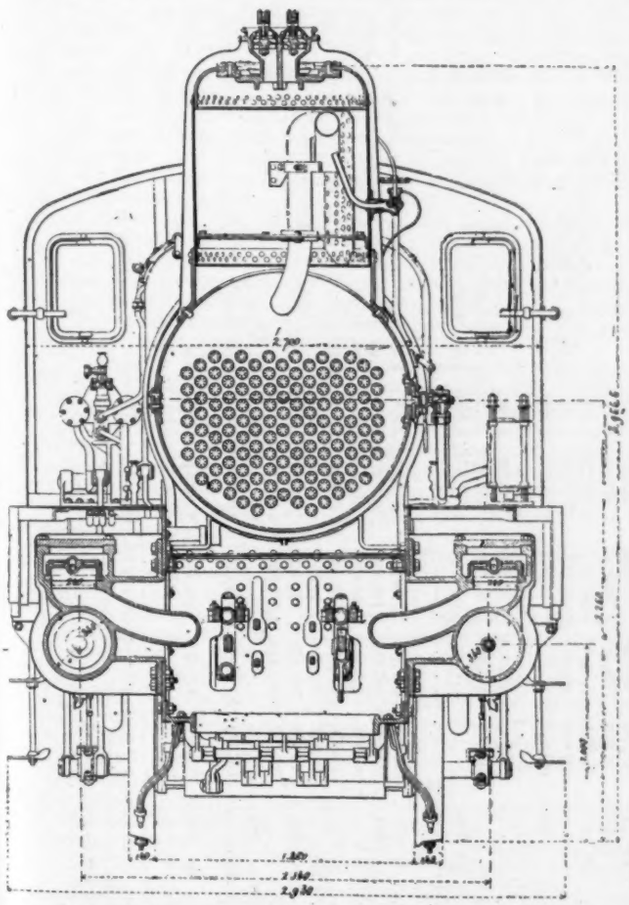
The blower sends steam into the stack through a crown of small holes in this central node.

The boiler is fed by two Sellers injectors of .25 in. and .3 in. nozzles. The cylinders are oiled by a double Mollerup-Dreval lubricator.

The pistons are of cast iron, and the rods are of steel screwed into them. The cranks and pins are of steel. Steel is also used for the axles; the wheel-centers are of iron and the tires of steel. As the crank-axle is not required to carry any eccentric, its two cranks are connected by a straight piece running direct from one to the other. The cranks are banded with a steel hoop, and the pins are traversed through their centers by an iron safety bolt.

The driving-boxes are of the Raymond-Henrard type with three wearing strips, one of which is below and the other two on the sides. Each of the driving-wheels are provided with a brake-shoe which is operated by the Westinghouse automatic apparatus.

The following is a list of the principal dimensions of the engine for which, as well as for the illustrations and the general description, we are indebted to the *Revue Générale des Chemins de Fer*:



CROSS-SECTION THROUGH HIGH-PRESSURE CYLINDERS.

Grate:

Length	7′ 3.9″
Width	3′ 4.9″
Area	24 sq. ft.
Inclination	20° 40′

Firebox:

Height inside (measuring to the bottom of the mud-ring)		front	5′ 11.5″
		back	3′ 10.1″
Inside length		top	7′ .24″
		bottom	7′ 3.9″
Width inside		top	3′ 6.5″
		bottom	3′ 4.9″
Thickness of steel	side and back sheets		.39″
	tube sheet	at tubes	.78″
		below tubes	.39″

Tubes (Serv6):

Metal	Steel.
Number	133
Outside diameter	2.5″
Thickness	.1″
Number of wings in each tube	8
Height of wings	.47″
Average thickness of wings	.10″
Length between tube sheets	9′ 10.1″

Heating Surface:

Firebox (from top of mud-ring)	112.16 sq. ft.
Tubes (inside surface)	1478.74 "
Total	1590.90 sq ft.
Ratio of heating surface of tubes to firebox	13.18 to 1
" " total heating surface to grate area	63.70 " 1

Boiler:

Outside length of firebox			7′ 10.4″
" width " "		top	4′ 4.7″
		bottom	3′ 11.2″
Inside diameter of main course of shell			4′ 4″
Length of shell			9′ 5.8″
Thickness of shell sheets			.6″
Metal in shell			Steel.
Inside length of smoke-box			5′ 4.96″
" diameter of smoke-box			5′ 1.3″
Top of rail to center of boiler			7′ 4.8″
" " " " bottom of front end of mud-ring			2′ 2.8″
Volume of water with 4″ over the crown-sheet			761.68 galls.
" " steam space			77.68 cu. ft.
Total capacity of boiler			1342.76 galls.
Steam pressure per sq. in			213 lbs.

Stack:

Inside diameter of stack	1′ 9.3″
Diameter of central ring of stack	10.6″
Height from top of smoke-box to top of stack	4′ .1″
" " " rail " " " "	13′ 11.6″

Areas of Air Passages:

Through grate		13.48 sq. ft.
" tubes	at firebox ferrules	2.79 "
	" center	3.70 "
Free inside section of stack		1.80 "
Ratio of stack to tubes		1 to 1.52

Frames:

Inside to inside of frames		4′ 1.2″
Thickness		.8″
Outside to outside of foot-plates	front	8′ 2.4″
	back	9′ 6.1″
Length over buffers		30′ 9.5″
Distance between axle centers	first and second	6′ 6.7″
	second and third	7′ 2.6″
	third and fourth	8′ 10.3″
	total wheel base	22′ 7.6″

Wheels and Axles:

Diameter of wheels	truck	3′ 3.4″
	driving	6′ 6.7″
Lateral play of the bogie		.6″
" " " drivers each way		.04″
Distance between inside of tires		4′ 5.5″

Cylinders:

	High Pressure.	Low Pressure.
Number of cylinders	2	2
Diameter " "	1′ 2.5″	1′ 9.8″
Stroke of pistons	2′ .4″	2′ .4″
Cross section of cylinders	.98 sq. ft.	2.5 sq. ft.
Volume of one cylinder	1.98 cu. ft.	1.48 cu. ft.
Center to center of cylinders	7′ .24″	1′ 11″
Length of connecting-rods	7′ 8.5″	5′ 10.8″
Ratio of rods to half stroke	7.58 to 1	5.8 to 1
Inclination of cylinders	0	0

Angular advance of L. P. ahead of H. P. cranks.... 135°

Valve Motion:

		High Pressure.	Low Pressure.
Type	Walschaert		
Kind of valve		Allan.	Allan.
Valve	length	1′ 2″	1′ 3.7″
	breadth	10.4″	1′ .87″
	area	.96 sq. ft.	1.37 sq. ft.
Maximum throw of valve		4.8″	5″
Outside lap		1″	1.4″
Inside "		0	0
Average maximum steam admission per cent.		72.5	75

Steam Passages:

Length of ports	9.4″	1′ 1″
Area of steam ports	.03 sq. ft.	.06 sq. ft.
" " exhaust ports	.075 "	.13 "
Steam pipe (area)	.10 "	.17 "
Exhaust pipe (area)	.17 "	.24 "
Volume of receiver	9.18 cu. ft.	

Weights:

Engine, empty		98,500 lbs.
In working order	truck axles (each)	19,580 "
	front drivers	33,370 "
	back "	33,290 "
Total		105,820 "

LOCOMOTIVE RETURNS FOR THE MONTH OF FEBRUARY, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage.					Av. Train.		Coal Burned per Mile.						Cost per Locomotive Mile.							Cost per Car Mile.		Cost of Coal per Ton.
			Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Passenger Cars.	Freight Cars.	Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Passenger.	Freight.	
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Alabama, Great Southern	....	....	.....	.....	.....	.....	.....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Alabama & Vicksburg	....	....	.....	.....	.....	.....	....	....	....	....	....	...	....	....	....	...	....	...	...	...	....	....	....	...	....
Atchison, Topeka & Santa Fé	834	723	.....	.....	.....	2,061,556	2,851	....	....	....	....	....	94.56	....	...	5.43	7.76	0.27	0.17	6.78	1.60	22.01	....	....	1.56
Canadian Pacific	612	....	445,782	678,693	303,952	1,428,417	2,333	....	....	....	....	....	82.45	....	....	4.45	13.74	0.43	....	5.79	1.53	25.94	....	2.57	3.29
Chic., Burlington & Quincy	545	....	.....	.....	.....	1,770,410	3,248	4.75	16.21	....	....	....	99.05	....	....	4.89	6.99	0.27	0.36	6.45	0.10	19.06	....	....	1.41
Chic., Milwaukee & St. Paul	825	....	.....	.....	.....	2,678,701	3,244	....	....	....	....	....	79.26	....	....	4.41	8.11	0.30	...	6.86	....	19.68	....	....	2.00
Chic., Rock Island & Pacific	552	....	500,176	871,967	403,656	1,775,799	3,217	....	....	....	....	....	72.72	....	....	3.06	7.11	0.27	3.06	5.97	0.42	18.83	....	....	2.70
Chicago & Northwestern	888	....	634,864	1,272,480	637,156	2,544,500	2,865	....	...	....	....	....	98.96	....	....	4.08	9.19	0.39	....	6.53	0.96	21.15	....	....	1.84
Cincinnati Southern	....	....	.....	.....	.....	.....	....	....	....	...	....	....	....	....	....	....	....	....	...	....	....	....	....	....	....
Cumberland & Penn*	22	21	4,664	33,044	.....	37,708	1,795	....	....	....	....	....	91.07	....	...	10.73	4.94	0.41	....	...	1.96	18.04	....	....	....
Delaware, Lackawanna & W. Main L.	210	189	.....	.....	.....	624,104	3,302	....	....	....	...	....	91.49	....	....	3.19	7.21	0.39	...	6.62	....	17.41	....	....	...
Morris & Essex Division	159	..	152,983	146,439	97,652	397,074	2,497	....	....	...	....	....	69.90	....	....	4.13	10.95	0.41	....	7.22	....	22.71	....	....	3.10
Hannibal & St. Joseph	76	...	.....	.....	.....	256,875	3,669	5.28	15.13	....	....	....	96.11	....	....	4.02	6.18	0.16	0.40	6.32	0.04	17.12	....	....	....
Kansas City, F. S. & Memphis	146	....	91,032	282,333	116,509	489,874	3,355	....	....	....	....	....	73.85	....	....	3.12	6.03	0.28	0.43	7.40	...	17.26	....	....	1.60
Kan. City, Mem. & Birm	42	37	32,735	58,739	12,583	104,057	2,812	....	....	....	....	...	72.46	....	...	3.99	3.92	0.24	0.36	6.96	....	15.47	....	....	1.04
Kan. City, St. Jo. & Council Bluffs	....	39	57,370	45,444	38,329	141,143	3,714	....	....	....	....	. ..	71.12	16.23	5.84	3.25	6.68	0.15	0.35	5.85	0 05	. ..	....	....	1.99
Lake Shore & Mich. Southern	594	....	399,805	889,199	501,186	1,790,190	3,013	....	....	72.62	99.90	39.83	76.95	....	....	2.96	6.13	0.12	....	7.12	0.18	16.51	....	...	1.59
Louisville & Nashville	....	343	397,855	694,512	425,512	1,517,879	4,425	5.15	16.11	69.62	101.48	58.63	91.45	13.61	7.34	3.46	6.05	0.24	1.35	5.00	0.30	13.44	3.28	1.54	1.58
Manhattan Elevated	....	295	709,290	.....	56,976	766,266	2,597	....	....	...	....	....	48.87	....	....	2.40	9.90	0.30	....	8.90	....	21.50	....	....	3.96
Mexican Central	....	....	.....	.....	.....	.....	....	..	...	....	....	....	....	....	....	....	...	....	....	....	....	....	....	....	...
Mil., L. S. & Western	112	....	69,875	118,664	84,851	273,390	2,440	....	.. .	....	....	....	88.49	....	....	3.55	12.32	0.24	....	6.55	1.03	23.69	....	....	2.80
Minn., St. Paul & Sault Ste. Marie	...	....	53,253	156,907	37,152	247,312	....	4.14	14.55	....	....	....	98.52	....	....	5.29	16.32	0.29	...	7.03	....	28.93	....	2.85	3.31
Missouri Pacific	339	304	.....	.....	.....	1,024,331	3,369	4.32	16.03	....	....	...	96.28	....	....	6.33	6.78	0.33	1.40	6.53	1.70	23.07	....	....	1.38
Mobile & Ohio	....	....	.....	.....	.....	.....	....	. ..	....	....	....	....	....	....	....	....	...	....	....	....	....	....	....	....	....
N. O. and Northwestern	....	....	.....	.....	.....	.....	....	....	....	....	....	....	...	....	....	....	...	....	....	....	....	....	....	....	....
N. Y., Lake Erie & Western	....	613	415,573	839,548	260,901	1,516,022	2,473	4.40	18.90	96.70	140.70	162.10	....	22.10	7.40	5.44	9.02	0.39	2.14	7.47	1.21	25.67	....	2.20	1.53
N. Y., Pennsylvania & Ohio	....	260	123,588	397,752	138,834	660,174	2,539	5.20	17.00	86.70	149.30	185.90	....	16.50	8.80	4.07	7.06	0.32	2.43	7.00	1.05	21.93	....	1.95	1.12
Norfolk & Western, Gen. East. Div.†	....	....	106,560	255,934	52,069	414,563	2,607	4.60	20.30	54.90	125.00	....	....	11.90	6.20	6.00	3.70	0.70	....	....	....	10.40	....	....	....
General Western Division†	....	....	94,376	266,423	36,046	396,845	2,634	5.32	15.47	76.00	140.00	....	125.00	14.25	8.77	5.71	4.56	0.66	....	....	....	10.93	....	....	....
Ohio and Mississippi	116	...	131,053	159,716	78.654	369,423	3,184	....	....	....	....	....	84.74	....	....	3.00	3.68	0.23	1.24	5.45	1.43	15.03	....	....	0.85
Old Colony	....	228	312,513	114,794	122,540	549,837	2,412	...	....	....	....	....	65.59	...	....	3.64	12.33	0.63	....	6.84	0.81	24.25	....	...	3.75
Philadelphia & Reading	....	....	430,709	332,623	1,016,859	1,780,191	.. .	....	....	....	....	....	78.30	....	. ..	4.95	9.67	0.38	....	6.04	0.37	21.41	....	....	....
Southern Pacific, Pacific System	..	720	.....	.....	.....	1,527,423	2,121	....	....	....	....	....	68.30	....	....	6.09	17.22	0.34	1.50	7.32	1.85	34.32	....	.. .	5.11
Union Pacific	998	....	658,195	1,173,439	450,616	2,282,250	2,287	5.34	16.03	....	.. .	....	104.10	17.09	9.01	6.95	9.96	0.44	1.00	8.19	1.18	27.72	4.90	2.16	1.91
Vicksburg, S. & P	....	...	.....	... .	.....	.....	....	....	....	....	....	....	....	..	...	..	....	....	....	....	....	....	....	....	....
Wabash	425	356	361,003	650,273	269,264	1,280,540	3,597	4.87	12.91	...	....	....	96.01	15.78	7.44	3.95	5.32	0.32	....	6.35	0.90	16.84	...	...	1.10
Wisconsin Central	149	112	121,989	189,176	63,726	374,891	3,347	....	....	....	...	...	99.10	....	....	4.04	11.85	0.30	....	7.53	....	23.72	....	....	2.36

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

It may be repeated here that the object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help us to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in April, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN APRIL.

Red Oak, I. T., April 3.—Engine No. 2 of the Choctaw Coal & Railway Company, hauling an east-bound way freight train, exploded as it was leaving the boundaries of this town, causing the death of four trainmen. They were: I. P. Durnell, engineer; F. Fredericks, fireman; a brakeman and hostler. One of them, who was riding on the pilot, was found under the engine trucks. The other three, who were in the engine cab, were thrown 80 ft. from the engine.

Edwardsville, Ill., April 4.—C. Alspaugh, an engineer. James Hambly and Hugh Woods, firemen, were killed, and Walter McGarrighan, engineer, was badly injured in a collision on the Jacksonville Southern Railroad near the place named. A number of other railroad and other employés were killed and injured.

Pittsburgh, Pa., April 4.—In a rear-end collision, near Packsaddle, on the Pennsylvania Railroad, Harry Brautlinger, engineer, had his nose broken, head cut, and arms and shoulders badly bruised, and A. W. Marsh, fireman, had his face badly cut and legs bruised. An engine was smashed and eight cars were demolished. A number of other employés were so seriously hurt that they will probably not recover.

Niagara Falls, N. Y., April 4.—The express and passenger train on the Niagara Central Railroad, which left St. Catharines, Ontario, at 3 o'clock to-day for this city, was derailed in a cut this side of Thorold, Ontario, and the engine and five freight and express cars were ditched. None of the passenger cars were derailed, and fortunately no passengers were injured. James McDonald, fireman on the engine, jumped and broke his arm. He was the only man hurt. The accident was caused by the rails spreading.

Rochester, N. Y., April 6.—Fireman Becker, of the West Shore, fell from engine No. 51, striking a switch post. His head is badly cut.

Delhi, Ind., April 7.—A terrible rainstorm weakened the bridge over Wildcat River, near Rossville, and the northbound Monon vestibule train went through the bridge, killing the fireman, O'Brien, of Lafayette. His body was caught under the locomotive. The engineer, Brooks, escaped with slight injuries.

Baker City, Ore., April 8.—Al Stevens, engineer, and Fred Phelps, fireman, were injured on the Union Pacific Railroad, but we have no other report of the accident.

Harrisburg, April 8.—James Moses, fireman, had been standing on the tank of a Pennsylvania Railroad engine when his head was caught by a wire and he was thrown to the ground. His head was badly cut, and he laid unconscious for over five hours.

Cincinnati, April 8.—An engine on the Louisville, New Albany & Chicago Railroad went through a bridge near Frankfort, Ind., Saturday morning. Engineer was killed and fireman fatally injured.

Rossville, Ind., April 8.—A passenger engine ran into some timbers lying on a bridge. The shock was sufficient to break the trestle and the engine dropped through, turning over as it struck the ground, holding the engineer and fireman in the wreck. The momentum of the train was so great that, though the trucks of the baggage-car and smoker fell down on the engine, the two cars were forced over and remained on the trestle beyond with no wheels under them. The passenger coach passed half-way over the break, its forward truck dropping down and the rear truck stopping on the track at the edge of the hole. This left the coach directly over the break in the bridge. The three sleepers were comparatively uninjured.

Every effort was at once made to rescue the fireman and engineer. The former was first liberated from the wreck, but was so badly hurt that he survived but a few minutes. It was nearly daylight when Engineer Brooks was rescued. He was found to be so badly injured that there are but slight hopes of his recovery. One leg was broken, the other terribly mutilated, and his back is severely hurt. He was held down by pieces of the engine or cab, and was extricated only after several hours' hard work by the passengers and crew of the train.

Green Brook, N. J., April 10.—While the Eastern express was going about 60 miles an hour, the report before us says, "Suddenly there was a terrific jerk and whizzing sound, followed by a succession of shorter jerks and a loud crash. Both driving-rods had snapped at the same time, and were thrashing through the air with the revolutions of the wheels.

"Joseph Lutz, the engineer, applied the brakes, and the engine, suddenly brought to a stop, reared on end, but came down on the rails again. The cars rebounded with the shock, knocking the passengers against one another and throwing to the floor several who had risen.

"Just as the brakes were applied the rod on the engineer's side came up through the iron floor of the cab and tore a hole in the boiler. The escaping steam scalded the engineer badly about the face, but he kept his post until the train came to a standstill."

Whether it was the main connecting or the coupling-rods which broke is not clear from the above account. Probably it was the latter.

Rome, Ga., April 11.—In a collision of two freight trains on the East Tennessee, Virginia & Georgia Railroad at Brice's, the engineers and firemen escaped by jumping, but one fireman fell head first and lost one eye and received some bad bruises. The others were severely bruised, but there was nothing fatal.

Macon, Ga., April 11.—A freight train was wrecked on the Southwestern Railroad, near Butler. Engineer R. F. Reeves, of Macon, jumped from the engine and was severely hurt on the right shoulder, a gash cut on his head, and injured internally.

Norwalk, O., April 11.—As a passenger train reached the Newton Street crossing, Frank P. Mitchell, an engineer on the Wheeling & Lake Erie Railroad, attempted to jump from the rear car. In jumping his heel struck a heavy plank, tearing the heel from his shoe and throwing him head first against the carsteps. A big hole was knocked in the back of his head, exposing the brain. Chances are against his recovery.

Canton, O., April 15.—While I. R. Whitman, an engineer on the Cleveland, Lorain & Wheeling Railroad, was running his train in on the weigh switch at Chamberlain, one of the rails under the engine turned, throwing the engine down the embankment a distance of 30 ft., and dragging three cars with it. Whitman saw the engine start and leaped out of the cab through the fireman's window. He fell on the rails and struck on the spinal column Paralysis of the lower portion of his body ensued, and he died about 10 o'clock Sunday morning.

Fireman Walker, of Lorain, was also in the cab, and not discovering the accident until too late to leap, clung firmly to the engine and came out without a scratch. The engine in going down the embankment made one complete revolution and half of another, and is a complete wreck. How the man in the cab escaped is a mystery to those who saw the accident.

Waco, Tex., April 17.—An incoming cattle train on the San Antonio and Aransas Pass Railroad ran into an empty train standing on the main track at this station this morning. The cattle train engine, which was just out of the shops, was completely wrecked. Fireman Smith was caught in the ruins and scalded to death. Engineer Browning was scalded, had his left arm broken, and received internal injuries.

Toledo, O., April 17.—A new mogul engine which was put on the Toledo, Ann Arbor & North Michigan Railroad four months before was in charge of Engineer Cavanaugh and Fireman Thomas C. Wilson, the latter a new man from Pontiac, Mich. Cavanaugh telegraphs that about a mile north of Emory, while going slow, the crown sheet let down, and the escaping steam scalded Fireman Wilson so badly that he died soon after.

Rochester, N. Y., April 17.—A fast mail train on the Auburn Road collided with a line of freight cars this afternoon. Engineer John McMannis jumped from the cab just before the crash came. His head struck a projection of the mail car, and his blood and brains were scattered over the entire side of the postal coach. Clarence Aldrich, the fireman, remained in the cab, crouching close behind the boiler

and escaped with no serious injuries. Several other railroad employés were injured.

Port Jervis, April 19.—Engineer O. H. Davis, who runs the fast train over the New York, Oswego & Western Railroad, met with what might have been a serious accident on Wednesday. He was looking back from the window of his cab when his head came in contact with the mail bag hanging on the crane at Parksville. The blow rendered him unconscious for a time, but he rallied, and proceeded with his train to Hancock. An examination of his injuries showed that he was badly bruised.

Whatcom, Wash., April 22.—Charles Welcome, a fireman on the Bellingham Bay & British Columbia Road, had three ribs broken by falling from the engine this morning. He was reaching over the water tank to get a tool from the tool-box, and was struck by one of the poles which hold the feed wire of the electric road.

Albuquerque, N. M., April 24.—In jumping from a derailed engine on the Atlanta & Pacific Railroad, Harry D. McCarty was injured—hip probably broken.

Somerset, Pa., April 26.—In coming down a grade of 150 ft. per mile on the Bare Rocks Railroad, at Ways Station, a train became unmanageable and dashed down the grade with frightful velocity. At the foot of the incline were several loaded freight cars, into which the passenger train plunged. On the engine were Engineer Neff, his son, and John E. Pyle, with his wife and daughter.

The three latter were hurled under the engine as it leaped from the truck and were instantly killed. Neff and his son were fatally scalded. On the cars were a large number of workingmen, some of whom jumped from the runaway train and escaped with slight injuries.

The balance were crushed in the wreck. How many is not yet known. Seven bodies have already been recovered.

Jacksonville, Ill., April 26.—While his engine was standing on the track near the junction, where there is a slight grade, Hardin Garner, engineer, was in the act of blocking the wheels of the locomotive to keep it from moving, and his hand was caught between one of the large drivers and the rail, and two of the fingers on his left hand were cut off at the knuckles and part of the third finger badly mashed.

Albuquerque, N. M., April 26.—The crown-sheet of a passenger engine gave way at Cerrillos, followed by an explosion strong enough to lift the engine from the track, and throwing the big machine on her right side. The explosion tore up the track for some lengths, and the trucks under the mail and express cars flew the track, both cars being twisted to the left of the engine. The engineer, Ed Keene, and fireman, Isaac Taylor, were both badly injured, especially Keene, who is hurt about the face, head, and legs. Taylor is pretty badly bruised about the body, but not dangerously.

Lansing, April 26.—When a mile west of Lansing a passenger train halted on the Chicago & Grand Trunk Railroad, and the signal of distress was given from the cab by means of the whistle. The conductor went forward to the engine, and found the engineer in a very sorry predicament. Coal gas had accumulated in the fire box, which had exploded, setting fire to Ryan's clothing. When aided by the conductor to a passenger-car the clothing that had not been burned off was removed, and as the gloves were pulled off the skin came with them. The fireman escaped injury by climbing through the cab window.

Aurora, Ill., April 27.—In a collision between a passenger train and switching engine on the Chicago, Burlington & Quincy Railroad, Engineer Damon was wedged in among the *débris* of the wrecked switch engine, and it was with considerable difficulty and hard work that he was extricated. It was found that his left leg was broken, his right foot badly smashed, and that he was otherwise bruised about the body.

Celeste, Tex., April 27.—A passenger train on the Gulf, Colorado & Santa Fé Road was ditched by running into a number of horses on the road. The engine and tender were completely demolished, the tender crushing in part of the baggage-car. Engineer Hardeman was almost killed, scalded all over with steam and hot water, and from his suffering must have been almost cooked. He was covered with mud almost beyond recognition when found. His wounds will probably prove fatal.

Fireman Bob Deering was scalded fearfully and burned, but no bones broken.

A number of other railroad employés were injured.

Ansonia, Conn., April 27.—G. W. Lamb, a fireman on the Naugatuck Division of the Consolidated Road, was painfully injured. While at Beacon Falls, he stepped out on a platform at the side of the boiler. He was engaged in cleaning the boiler when his right leg slipped through an opening. He lost his balance and slipped over the side of the engine. Both bones in his right leg were snapped at the ankle.

Ann Arbor, Mich., April 28.—In a collision which occurred in a snowstorm near Emory, on the Toledo, Ann Arbor & North Michigan Road, the fireman was caught in the gang-way on the right side between the cab and tank. We had to saw away the cab, and it was 40 minutes before we got him out. He was still alive and rational, and lived about 25 minutes. This was the first trip of the fireman. The engineer, J. Anderson, was also injured.

Pittsburgh, April 29.—A passenger train on the Baltimore & Ohio Railroad collided with a freight train at Griffin Station, near West Newton. Fireman Thomas Nevill, of the freight, received painful injuries.

The freight train was crossing from the east to the westbound tracks to get out of the way of the "flyer." The collision occurred at the cross-over switch.

A conductor and passenger were also injured.

Los Angeles, Cal., April 30.—Engineer Harry McCarty was caught in the Atlantic & Pacific freight wreck near Grants, had both legs broken, one of them in two places. He also sustained internal injuries. The wreck was caused by sand drifting upon the track.

Kansas City, Kan., April.—In a derailment in that city—of the date of which we are not advised—which was due to a "split switch," the engineer and fireman were killed. Of the accident it is said:

"At the first jar Engineer Popperts reversed his engine and whistled brakes. Then only did he attempt to escape. While the brave fellow was half-way out of the cab window the engine rolled over and crushed him almost to a pulp underneath. Every bone in his body was broken. Then, to make death's work sure, the burning hot boiler rested on his face, holding him, while the steam scalded his body, which, mercifully, was lifeless ere that.

"Fireman Gatchell, when he saw the danger, jumped from the left side of the cab, but he was caught under a box-car. Four of his ribs and his nose and upper jaw were crushed by an iron brake-rod. He was also terribly ruptured internally. After the crash he crawled out of the wreck and sat down on the ties of a sidetrack a few feet away."

Our report for April includes 32 accidents. In these seven engineers and nine firemen were killed, and 16 engineers and 13 firemen were injured. The causes of the accidents may be classed as follows:

Boiler explosions	3
Broken coupling-rod	1
Derailments	4
Collisions	8
Falling or jumping from engine	3
Went through bridge	3
Wreck	2
Jumping from car	1
Run-away train	1
Struck by objects	3
Gas explosion	1
Hand crushed	1
No cause given	1
	32

THE CONSOLIDATED CAR HEATING COMPANY'S ELECTRIC HEATER.

THE fact that the passage of an electric current through a wire will heat it has been made use of by the Consolidated

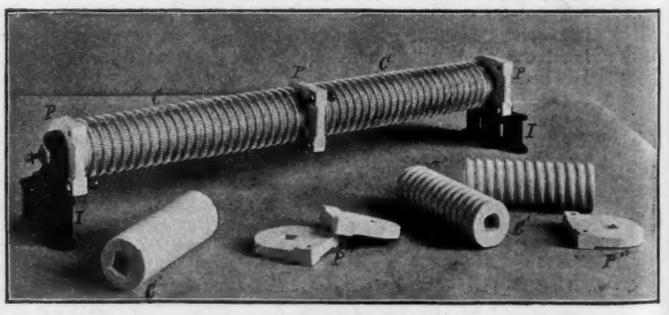


Fig. 1.

Car Heating Company of Albany, N. Y., for constructing a very convenient heater for electric cars, and for other purposes wherever an electric current is available.

The principle which governs the development of heat by electricity is stated as follows by this Company:

"The amount of heat given out is equal to the square of the quantity of current, measured in ampères, multiplied by the resistance of the conductor in which the heat is generated. The amount of heat given out by an electric heater placed between two conductors, in which a given difference of potential is maintained, therefore depends upon the resistance within the heater itself, and is, moreover, for a given difference of potential strictly proportional to the amount of current used."

In the heater, which is the subject of this article, the resisting conductors consist of iron wire .032 in. diameter wound on a mandrel $\frac{3}{8}$ in. diameter into helical coils. These coils are then wound on cylindrical glazed porcelain insulators 2 in. in diameter, which have helical grooves in them to receive the

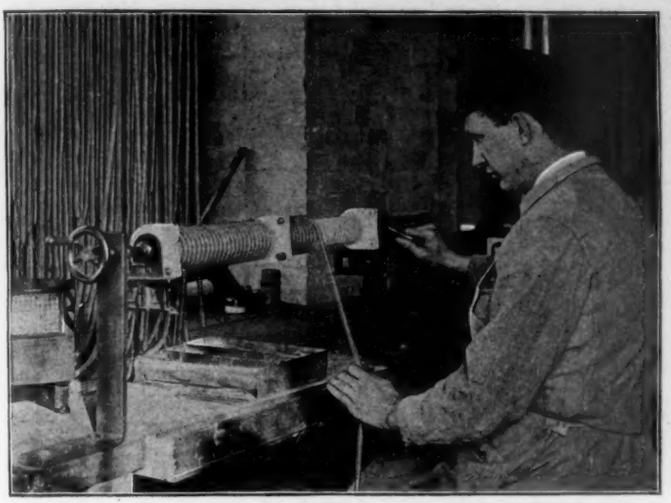


Fig. 2.

coils of wire. Some of these insulators, *C C*, with and some, *C' C'*, without the wire on them are shown in fig. 1. In fig. 2 the method of winding the coils on the insulators is shown. In this process the wire is drawn out sufficiently so as to prevent the neighboring convolutions of the wire from coming in contact with each other. The length of wire in a set of six heaters, a car equipment, is 2,550 ft., or nearly half a mile. The cores are mounted on a square $\frac{5}{8}$ in. iron rod, the aperture for which is plainly shown at *C' C'* in the detached cores in fig. 1. At the end of each core, which forms a division of the heater, a glazed porcelain plate, *P P*, is provided, in which binding screws are placed, to which the ends of the wire coils are connected. The cores are usually arranged in pairs, as shown in fig. 1, with a porcelain plate *P'* between them, so that the two sections may be connected independently if de-

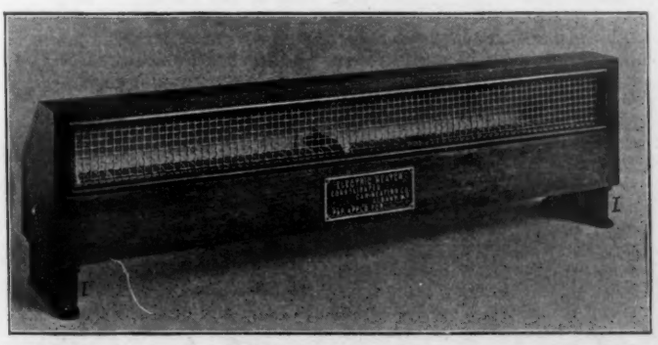


Fig. 3.

sired. The porcelain insulators are supported by the iron rods referred to, which are carried at the ends on cast-iron stands *I* and *I*. These are fastened to the floor of the car. The heaters are covered with a neat wooden box or case, as shown in fig. 3, the cast-iron stands *I I* serving also as supports for the case, which has an open front protected by a wire screen. The case is lined throughout with asbestos mill-board.

In cars provided with paneled risers under the seats the heaters are placed within the risers, as shown in fig. 4, so that

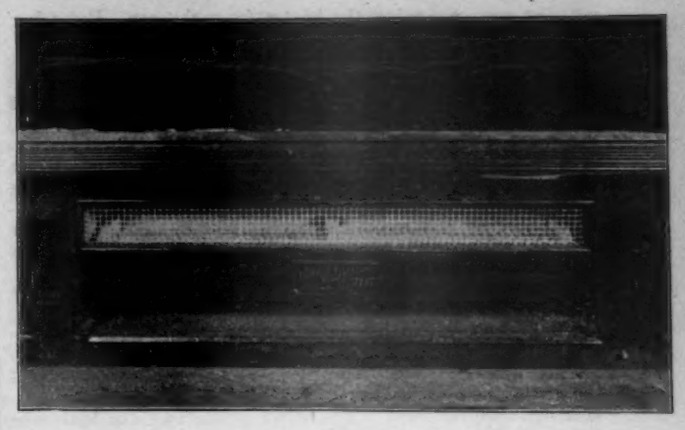


Fig. 4.

the front of the heater, with its grated openings, takes the place of the panel.

From figs. 3 and 4 it will be seen that the bottom of the wooden case stands a few inches above the floor. This allows cold air to flow into it where it is warmed by the coil, and then flows out through the grated opening into the car. The warm air thus communicates its heat to the feet of passengers before it rises to the upper part of the car.

In their descriptive circular the Consolidated Company say:

"To prevent the oxidation of the resisting conductor a galvanized wire is used which has the advantage of not oxidizing readily even when a high temperature is maintained. An

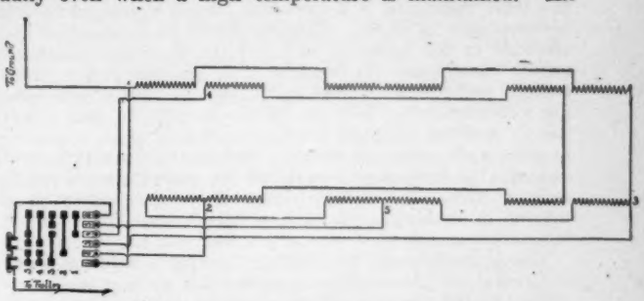


Fig. 5.

absolute assurance against any dangers from the oxidation of the conductor is secured by carrying in the resisting conductor a comparatively low temperature. To accomplish this, it is necessary to use a wire of considerable length, so that this wire may present a large heating surface and give off the desired amount of heat without the necessity for a high temperature. Neither in actual use nor in long-continued experiment has a heater failed from oxidation of the conducting wire. Should, however, a failure of the resisting conductor occur from accident or any cause, the coiled wire can be quickly and easily removed and a new wire be put in its place

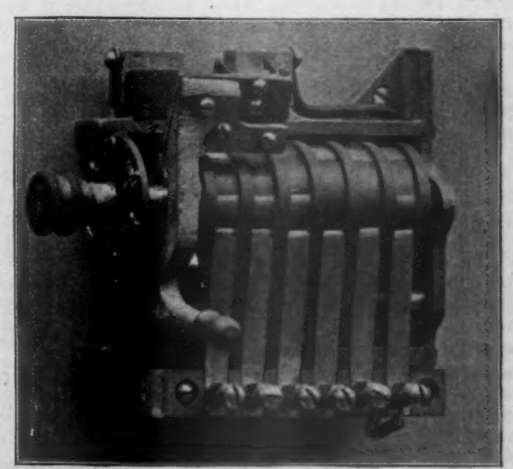


Fig. 6.

without even removing the heater from the car. But a few minutes are required to make a renewal of wire coil."

The Company also express the belief that when the thermometer is at zero, or below, that it will probably be necessary, during at least a portion of the day, to use about 12 ampères of current, if cars are effectively heated. Having determined the maximum amount of heat required in the coldest weather, the question then came up how to regulate the temperature in milder weather, so as to prevent the cars from being then overheated and a waste of electrical energy resulting in needless expense. The ability to vary and regulate the intensity of heat to meet the requirements of the weather was a necessary provision for a successful electrical heater.

In order to be able to regulate the heat, the heating coils are arranged as shown in fig. 5. An electrical switch, shown by fig. 6, is then provided which consists of a cylinder of insulating material which carries in fixed position on its circumference pieces of conducting metal. Proper connections of the metal contacts are made through the substance of the insulating material itself. The wires connecting the heaters in the several combinations necessary to obtain the different intensities of heat are connected to binding posts in the switch, and terminate in multiple spring contacts resting upon the surface of the cylinder carrying the contacts above described.

The switch has six different positions. In one position the circuit is open (no heat), and the remaining five positions give different intensities or grades of heat. Different combinations of the electric heaters are made by the different positions of the switch, so as to increase or decrease the flow of current to correspond with the increase or decrease in the intensity of heat required.

In the first position of the switch all of the heaters are placed in series, so that the current from the trolley must pass through their combined resistance. In the second position one third of the total resistance is thrown out, the remaining two-thirds being placed in series. This results in an increase of about one-half in the intensity of heat. In the third position the switch recombines the heaters in a multiple series of two, thereby still further increasing the flow of current and obtaining a corresponding increase in the intensity of heat. In the fourth position the total heating surface is again recombined in such a way that one-third of the electric heaters is thrown out, and the remaining two-thirds are combined in a multiple series of two. In the fifth position the remaining one-third is thrown in, making a multiple series of three. The switch is inclosed in a neat wooden case not shown in our engraving.

The Consolidated Car Heating Company estimate that the additional cost incurred to generate the current necessary to supply electric heaters will be from one-half to three cents an hour to heat a car by this system.

PROCEEDINGS OF SOCIETIES.

Master Car-Builders' Association.—The Twenty-seventh Annual Convention of the Master Car Builders' Association for 1893 will be held at Lakewood, N. Y., with headquarters at the Kent House, commencing Tuesday, June 13, 1893.

There are two hotels near together, and the proprietor of the Kent House will receive all applications for rooms and locate the guests. His address is Jno. C. Brady, Kent House, Lakewood, on Lake Chautauqua, N. Y. The hotels agree to a uniform rate of $3 per day when nothing extra is wanted. Messrs. R. C. Blackall, T. A. Bissell, and Angus Sinclair are a Committee of Arrangements for this Convention.

American Railway Master Mechanics' Association Annual Convention.—The Twenty-seventh Annual Convention of the American Railway Master Mechanics' Association for 1893 will be held at Lakewood, N. Y., with headquarters at the Kent House, commencing Monday, June 19, 1893. There are two hotels close together, and the proprietor of the Kent House will receive all applications for rooms and locate the guests. His address is Jno. C. Brady, Kent House, Lakewood, on Chautauqua Lake, N. Y. The hotels agree to a uniform rate of $3 per day when nothing extra is wanted. Messrs. R. C. Blackall, T. A. Bissell, and Angus Sinclair are a Committee of Arrangements for this Convention.

Engineers' Club of Cincinnati.—At the last regular meeting of the Club Mr. E. F. Layman read a paper on Sidewalk Improvements in the Vicinity of Cincinnati, which comprised a review of the legislation enacted by the State of Ohio in the last few years pertaining to the construction of and manner of payment for sidewalk improvements, and a description of the proper construction, workmanship and materials necessary to secure the best results in building artificial stone sidewalks, which have been very generally adopted in the suburbs, an expenditure of $400,000 having been made on them in a few years.

Engineers' Society of Western Pennsylvania.—The February bulletin of the Society contains an article with a discussion on the construction and maintenance of the Howe truss bridges; also a short article on Segregation in Steel, by Walter E. Koch, who states that the method he has used for the last twenty years for the determination of sulphur in steel and pig iron is to take sulphuric acid, one part; water, four parts; mix, and when cold, pour on to five grammes of steel or iron in a flask, and pass the evolved gases into a cold saturated solution of cupric sulphate. In a few moments it will be possible to tell just how the sulphate stands. The method works better for steel than pig iron, but is very useful and quick for both.

Mr. R. N. Clark also contributed an article on the use of boneblack for domestic filters, giving the detail of his experience and the good results that have been obtained by the use of properly constructed bone filters.

Engineering Association of the South.—The regular monthly meeting was held April 13. The feature of the evening was a discussion on High Duty Attachments for Non-rotative Pumping Engines, led by Mr. L. d'Auria.

Mr. d'Auria showed that, apart from any consideration relating to expansion, the aggregate weight of the reciprocating parts in the Cornish engine is 2.3 times the weight of the load; in the Bull engine, equal to the load, and in the Worthington, one-tenth the load, though it could be made heavier without restriction; but, with reduction of weight in these three successive types of engines, the rate of steam expansion had also to be reduced, it being possible to use in the Cornish engine four expansions, in the Bull but two, while in the Worthington simple cylinder expansion was practically impossible.

Mr. d'Auria showed that the piston speed is affected by what he calls "effective weight;" this weight being expressed by the sum of the products of each of the reciprocating parts by the square of the velocity of its center of gravity or gyration, expressed in terms of the velocity of the plunger as a unit. In using steam expansively, this force in the first part of the stroke is greater than the load, and will perform an excess of work, "accelerative work." According to a law discovered by Mr. d'Auria, the mean plunger speed during the stroke in a non-rotative pumping engine equals

$$C\sqrt{\frac{\text{accelerative work}}{\text{effective weight}}},$$

the coefficient C varying with the variation of the propelling force, and in the average equaling about 4.8. By the application of this law, it was proven that the Bull engine could have been made lighter and yet used a higher rate of expansion than the Cornish, and that a Worthington engine could have been transformed into a high-duty engine by adding a reciprocating weight, about 7 or 8 per cent. of the load, and moving with a velocity four times greater than that of the plunger. This added reciprocating weight, which constitutes the D'Auria high-duty attachment, was shown in the form of a liquid column; thus, a direct-acting plunger is attached to an extension of the piston-rod of the pumping engine and moves in a cylinder of its own; at the ends of this cylinder the ends of a U-shaped pipe are attached, and the cylinder and pipe are filled with liquid. The area of the pipe being less than that of the plunger, the velocity of the liquid column is proportionally greater than that of the piston. Shocks due to excess of energy at the end of the stroke are prevented by passing the liquid around the plunger through small channels uncovered, when the plunger, by this excessive pressure, passes beyond its usual stroke. This feature, as well as the verification of the law of piston speed, was shown by a model in which the propelling force was a spring attached to one end of the plunger rod, the load being represented by a weight pulling at the other; these balanced only at the middle of the stroke, the pull of the spring at the beginning was about twice that of the weight, and at the end only equalled the friction of the working parts. When the apparatus was filled with liquid the piston made a steadier, longer stroke than when no liquid was used, showing the friction of the liquid to be insignificant. Diameter of the plunger, 3 94 in.; diameter of pipe, 2.06 in.; ratio of their areas, 3.65; weight of moving parts, 61 lbs.; weight of water in the pipe, 51.5 lbs.; hence the effective weight with the water is, $W = 61 + 51.5 \times 3.65^2 = 747$ lbs., and without the water is only $W = 61$ lbs. The accelerative work in both cases is $Q = 4.84$ foot-pounds, and the length of

stroke, 0.46 ft. The velocity was found to be with the water 0.383 ft. per second, and without the water, 1.33 ft. per second. According to Mr. d'Auria's approximate formula,

$$V = 4.8\sqrt{\frac{Q}{W}},$$

the velocities equal 0.384 and 1.34 ft. per second respectively, showing close agreement with experiment. Besides, the figures show that the effect of the water in the pipe was to reduce the piston speed to about one-third that without water, and that without appreciable loss by friction.

Engineering Society of the South.—At the regular meeting held at Nashville on May 11, there was a discussion on the durability of Yellow Pine, in which Mr. Hunter McDonald stated that he thought yellow pine was not as durable now as formerly, ascribing as one reason among others the common practice of tapping pine for turpentine; also the fact that much of the timber comes from "old field pine," the secondary growth which has followed the clearing of the original forests. He thought the theory erroneous that tapping removed the turpentine from the sap only and not from the heart, and that the whole stick is made more porous for the absorption of moisture. Some bridge timbers were sound after 14 years of service, while nearly all pine timber now has to be removed in five or six years. He does not now paint wooden members of bridges, but houses them, allowing free air circulation. In the Tennessee River bridge at Johnsonville are timbers housed and sound after 21 years of use. He believes that if timber could be protected two years, then well painted, it would add four years to its usefulness. He finds more difficulty judging when a stick is unsafe from decay than in protecting it, and thinks some practical test of timber in place would be of great benefit.

Mr W. C. Smith agreed that timber when from original forests and not tapped lasted better than otherwise, and called attention to the hastening of dry rot by confining timber in walls. The confined ends of joists have rotted in nine months when the rest was still good. In his practice he either leaves air space around the ends of joists or builds projecting bearings for them. Poplar timber sawn from river rafts decayed in two years when exposed to the weather, and at the same time lasted well on interiors.

PERSONALS.

MR. C. IRONMONGER has been appointed Eastern Passenger Agent of the Seaboard Air Line, with office at 229 Broadway, New York.

MR. J. J. RYAN, General Division Master Mechanic of the Southern Pacific, has been given charge of the entire Atlantic system of that road, including the ocean steamship service of the company.

MR. F. ROSENBERG, who resigned his connection with the Colorado Coal & Iron Company and the Bessemer Ditch Company of Pueblo, Col., on April 1, is now with Jutte & Foley, with an interest in the business.

MR. A. E. KENDAL has resigned his position as General Passenger Agent of the New York & New England Railroad, to assume the same position on the Old Colony Division of the New York, New Haven & Hartford Railroad.

MR. E. P. LORD, formerly Superintendent of Motive Power of the Cleveland, Cincinnati, Chicago & St. Louis Railroad, has accepted a position as General Manager in charge of construction with the A. K. Porter Company, Pittsburg, Pa.

MR. H. L. GANTT, late of the Midvale Steel Company, has been appointed General Superintendent of the American Steel Wheel Company, vice Mr. George W. Cushing, resigned. Mr. Gantt will have charge of the new plant at Garwood, N. J.

MR. F. A. SCHEFFLER resigned his position as General Superintendent of the Brush Company, of Cleveland, O., April 1, and has been appointed and accepted the position of General Sales Agent of the Stirling Company, manufacturers of the Stirling Water-Tube Boiler, with office at 74 Cortlandt Street, New York City.

NOTES AND NEWS.

The Rolling Stock of the Holland Railways is placed by the *Journal des Transports* at 715 locomotives, 1,833 passenger cars, and 9,860 freight cars. The annual service consists in the transportation of 22,185,182 passengers and 8,397,342 tons of freight, the ton-mileage not being given. The gross receipts for this service amounts to $11,985,422.83.

Signaling Direct to a Locomotive.—A method of signaling directly in front of the driver's eye is being tried on the Great Northern. Contact is made by a brush on the engine rubbing on a rail or wire. If a current is sent from the signal-box to the wire, the circuit is completed with the engine, and the little semaphore on the locomotive drops. Somewhat similar devices were shown at the Electrical Exhibition at the Crystal Palace 10 years ago, but they do not find much favor with railroad men.

Welding Steel.—The following process of welding steel is recommended in Germany: Heat in an iron vessel 64 parts of borax, 20 parts of sal-ammoniac, 10 parts of ferrocyanide of potassium, and 5 parts of colophony, all pulverulent, together with some water and a spoonful of brandy. Stir well; let cool in the vessel, and then stamp to a powder. The steel pieces to be welded are brought to a bright red heat at the weld-points, and the process is then conducted in the usual way with the help of the powder.

New Magazine Gun.—The new magazine gun invented by Lieutenant Henry K. White, U.S.N., has been completed at the Pratt and Whitney Works in Hartford and forwarded to Washington. The arm will be submitted to the Government Board, which has been ordered to reopen tests for magazine guns at Springfield, Mass. The system is what is known as "the straight pull," and the magazine contains five cartridges. Rim and "headless" ammunition can be adjusted for regular service with this arm. The inventor of the Durst magazine gun, who is now in Europe, is having a new gun made at Hartford, which will also be submitted to the Board for trial. The Durst gun was not completed in time for submission to the Board last summer.

Armor Plate Test for the "Texas."—A test, which resulted in the acceptance of 500 tons of armor plate for the *Texas*, was recently made at the proving grounds of the Bethlehem Iron Company by the representatives of the Government. It was a ballistic test. The test plate stood as a criterion of the redoubt armor of the steel armored battleship *Texas*, which is being built at the Norfolk Navy Yard by the Government. The test plate representing this important protective inclosure is 12 in. thick, 16 ft. long, and 8 ft. 4 in. high. It is perfectly flat and weighs 30 tons. This plate is composed of nickel steel forged on the big hammer and well tempered and annealed. Three shots were fired from the 8-in. gun. The missiles were 250-lb. Holtzen projectiles. The first shot was fired with a charge of 79 lbs. of powder, which developed a velocity of 1,678 ft. The projectile penetrated the plate, the tip just projecting on the other side, raising a rear bulge of about 2 in. The penetration was 14 in. The projectile rebounded and fell on the ground in front of the plate. The second shot was fired with a charge of 110 lbs. of powder, producing the extraordinary velocity of 2,004 ft. a second. The projectile penetrated the plate and backing. It did not rebound. The third shot, fired at a velocity of 1,835 ft. a second with 91 lbs. of powder, penetrated 15½ in. The projectile rebounded. All three were somewhat upset, but not broken. The points of impact were 28 in. apart. The plate endured the bombardment without damage, showing a remarkable resistance. It was not broken up in the least, nor were any radiating cracks developed.

Trans-Siberian Railway.—According to recent advices from St. Petersburg, work will be in progress during the coming season upon the following sections:

1. The Western Siberian Line, from Chelabinsk to the Obi River, 1,328 versts—885 miles—under charge of Chief Engineer Mikhailovski.

2. The Central Siberian Line, from the Obi River to Irkoutsk, 1,754 versts—1,170 miles—under charge of Chief Engineer Mejininov.

3. The Ekaterinburg-Mias Branch of 238 versts—159 miles—which will connect the Oural Railway with the systems of European Russia. This will also be under the charge of Mr. Mikhailovski.

The official programme adopted by the Ministry of Lines of Communication provides for the construction of the entire line from Chelabinsk to Vladivostok in 12 years. The pro-

gramme names the dates for completion of the several sections of the line as follows :

1. In 1894 the Oussouri Line, from Vladivostok to Grafskaia, and the Ekaterinburg-Mias Branch.

2. In 1896 the main line from Chelabinsk to Krasnoiarsk, including the entire Western Siberian Line and a portion of the central section.

3. In 1900 the remainder of the Central Siberian Line from Krasnoiarsk to Irkoutsk, and the extension of the Oussouri Line from Grafskaia to Khaborovka.

4. Finally, in 1904, the remainder of the main line from Irkoutsk to Khaborovka, including the Baikal loop, the Trans-Baikal Line, and the Amour Line.

The estimated cost of the entire line from Chelabinsk to the Pacific, 4,700 miles, may be given in round figures at $200,000,000.

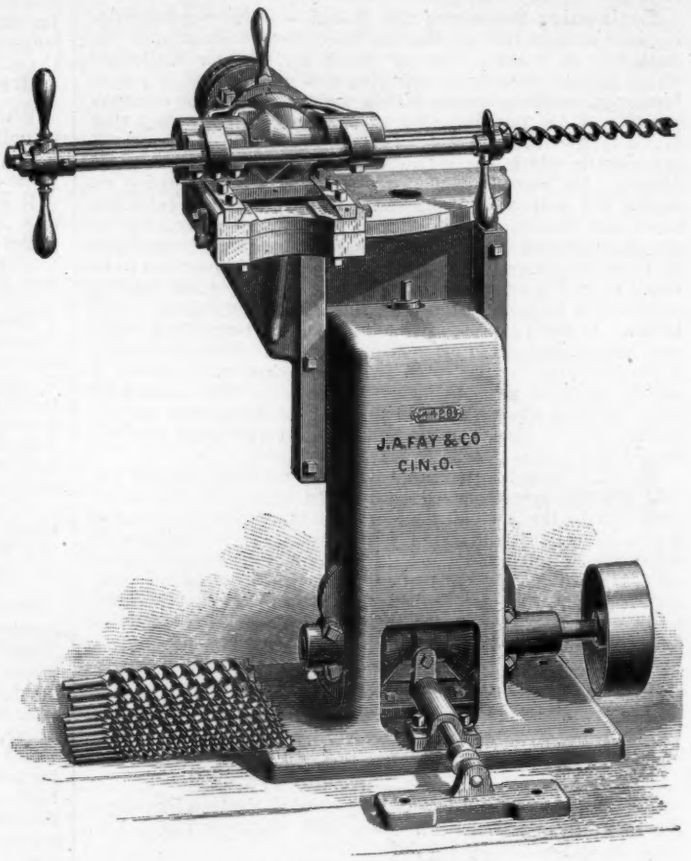
Manufactures.

RADIAL REVERSIBLE CAR-BORER.

THE radial reversible car-borer, which is herewith illustrated, is one that is built by the J. A. Fay & Egan Company, of Cincinnati, O., and is especially intended for the end-boring of car sills.

It is so arranged that it will bore at any angle of a horizontal or vertical plane. The column which forms the base-plate of the machine is of one piece, and a boring-spindle runs in a revolving frame, which can be reversed so as to bore either to the right or left, and can be moved through an angle of 90°. It is attached to a segmental plate supported and gibbed to the column. The vertical adjustment of the boring-spindle and the table is obtained by means of a heavy screw driven by friction at the base of the column. There is also a hand adjustment which can be used if desired. The boring spindle has a vertical movement of 8 in. and a horizontal one of 12 in., and will bore to a depth of 1 ft.

The boring can be done in the end of a car sill or stick parallel with its length for joint bolts, and at right angles for ordinary bolts. It has been especially designed for use in connection with the automatic railroad saw, built by the same makers, so that by means of the two machines the two operations of cutting the ends of the sills and boring without changing their position are accomplished at the same time.



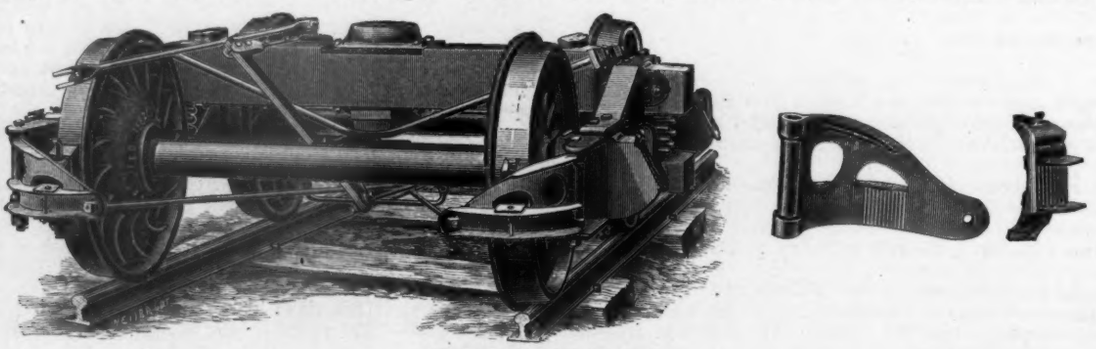
RADIAL REVERSIBLE CAR-BORER.

THE BEAMLESS BRAKE.

STATISTICS show that over 10 per cent. of the railroad accidents which occur in this country are due to detached brake-beams. They fall on the track and either derail some of the cars or detach more brake-beams, and thus produce what may be called a cumulative accident.

Having this danger in view, the Beamless Brake Company of 41 Dey Street, New York, and Bloomsburg, Pa., have brought out a truck which does not require any transverse brake-beams. This truck is shown by the engraving herewith. To each end of the truck side-frames a sort of bracket is attached by a vertical bolt, so that it can turn about the bolt like a hinge. These brackets are made of malleable iron, and, it will be seen, are curved inward from the end of the truck frame, so that they come opposite to and extend inside of the treads of the wheels. This bracket or curved arm or lever, as it may be called, has a corrugated inner surface, to which the brake-block is attached, so that it and the shoe can be shifted horizontally ¼ in. in either direction, and always be adjusted for a perfect fit on the wheel tread. Diagonal rods are connected to the inner ends of the brackets and are coupled to an equalizer and to the brake-levers. From this description, the operation of these brake-brackets will be apparent. If by any means they should be broken or detached from the truck frames, they would be less liable to throw cars off the track than a brake-beam is ; or if a person should fall under a train or be run over there will be more room below the trucks, so that the cars could pass over him without injury.

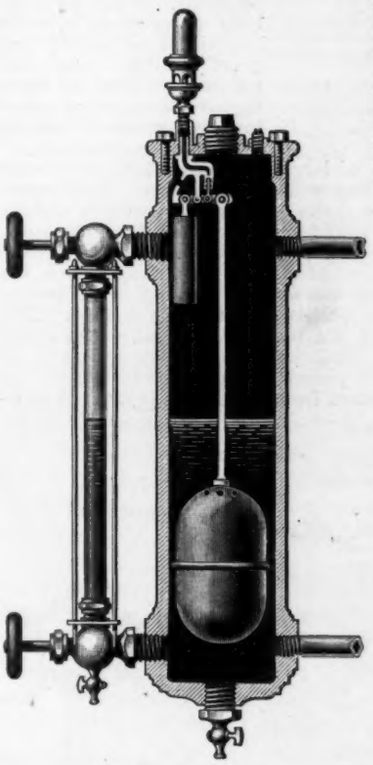
The brake-brackets are strong, simple and easy of access, to replace worn-out shoes, and can be seen easily by inspectors from the outside of the train. They are said to be perfectly noiseless, and have no vibration when in use, and the shoes have no tendency to "lop" over on the wheels when the brakes are not in use. No hangers or safety chains are required. A car with these brakes is on exhibition in the Transportation Building at the Columbian Fair.



THE BEAMLESS BRAKE.

ASHLEY'S COUNTERBALANCE LOW-WATER COLUMN.

THE cut shows a low-water alarm for steam boilers, which in its operative principle is based upon the difference in weight of a body suspended in air and immersed in water The alarm has the two connections to the boiler common to a water column, and is shown with gauge-glass attached. The cover of the alarm, which is fastened in place by tapped bolts, is removable, and to this is attached all the mechanism of the device. Suspended from the under side of the cover is a valve working in combination with a double-ended lever having its fulcrum between the two ends. From the ends of the lever two cylinders are suspended, the upper and smaller one of solid iron, and the larger hollow, with holes in its top, so that it is filled with water. When the water stands at the desired level in the boiler and column, the solid cylinder is heavier than the larger immersed cylinder, and consequently keeps the valve closed. As the water in the column falls, the hollow cylinder filled with water overbalances the weight of the solid cylinder when deprived of the buoyancy of the surrounding water, and opens the valve, admitting steam to the alarm-whistle. The solid cylinder regains its counterbalance on the admission of water to the boiler, closing the valve. This alarm, which is the invention of Frank M. Ashley, is made by the Ashley Engineering Company, Hawthorne, N. J.; New York office, 136 Liberty Street.



ASHLEY'S LOW-WATER COLUMN.

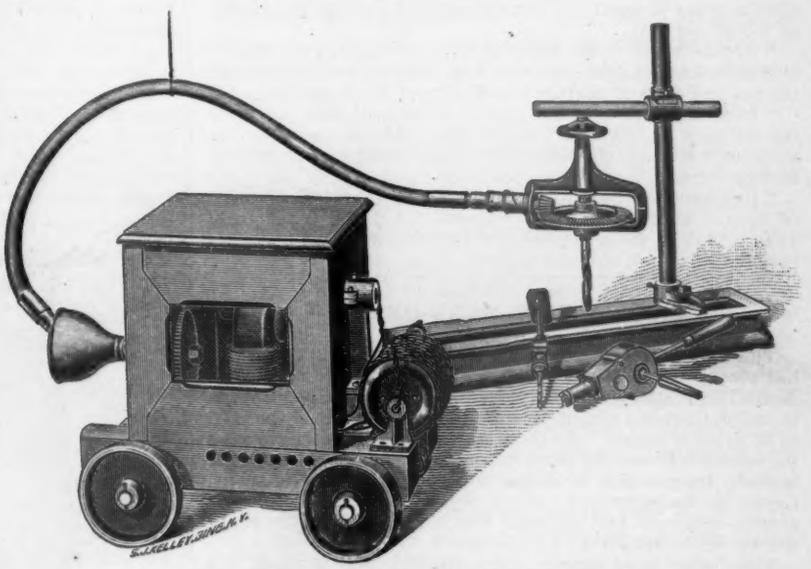
COMBINATION OF STOW FLEXIBLE SHAFT AND ELECTRIC MOTOR.

FOR nearly 20 years the Stow flexible shaft has been on the market in connection with various other tools designed and manufactured by the Stow Manufacturing Company, of Binghamton, N. Y., for drilling, tapping, and reaming.

Thousands of them are in use in the various railroad, machine, boiler, and bridge shops in both this country and Europe.

There has been for the past few years among the larger shops a growing tendency to increase the range of this tool beyond that for which it was originally designed. This demand has been met, from time to time, by increasing the length of the driving rope and adding extra idlers for support of same, but the objection has been urged that when traveling cranes or other overhead machinery were used, that the driving rope was in the way. These objections are overcome by the use of the flexible shaft in connection with a specially designed low-speed electric motor. This combination has been under advisement for the past two years, and as a result an electric portable drilling, tapping, and reaming plant, that can, without trouble or loss of time, be carried to any distance from the source of power, is offered to the public.

The motor has a normal speed of about 600, which can be increased by a rheostat to 1,000 and 1,200, and reduced by gears to 275 without loss of power. These motors are manufactured for a voltage of either 110, 220, and 500.



STOW FLEXIBLE SHAFT AND ELECTRIC MOTOR.

TEST OF CUT AND WIRE NAILS.

A COMMITTEE consisting of Charles L. Bailey, Arthur B. Clarke, and Horace P. Tobey, have made a report on the holding power of cut and wire nails. The tests were computed and arranged by Consulting Engineer William H. Burr, and were made on the United States Testing Machine at Watertown, Mass. The following is the substance of their report:

"At your request, I have examined, summarized and computed percentages upon the report of Major J. W. Reilly, of the United States Ordnance Department, giving in detail the tests made for ascertaining the relative holding powers of cut nails and wire nails, of equal lengths and weights; which tests were made at the United States Arsenal at Watertown, Mass., under the supervision of Major Reilly, in accordance with an invitation of the Eastern Cut Nail Manufacturers of the United States to the Wire Nail Manufacturers of the United States, dated November 4, 1892. The tests were made in November and December, 1892, and January, 1893.

"I find results as follows:

"The series of tests, each series comprising 10 pairs of cut nails and wire nails of one size, were, in number, 58.

"The number of nails tested was 1,160.

"The nails ranged in length from 1½ in. to 6 in.

"The number of series in which the cut nails showed the superior holding power was 58.

"The number of series in which the wire nails showed the superior holding power was not any.

"All the nails tested were driven in spruce wood.

"Additional tests were made, of the box nails only, in pine wood.

"In spruce wood, in nine series of tests, comprising nine sizes of common nails (longest 6 in., shortest 1½ in.), the cut nails showed an average superiority of 47.51 per cent.

"In spruce wood, in six series of tests, comprising six sizes of light common nails (longest 6 in., shortest 1½ in.), the cut nails showed an average superiority of 47.40 per cent.

"In spruce wood, in 15 series of tests, comprising 15 sizes of finishing nails (longest 4 in., shortest 1½ in.), the cut nails showed an average superiority of 72.22 per cent.

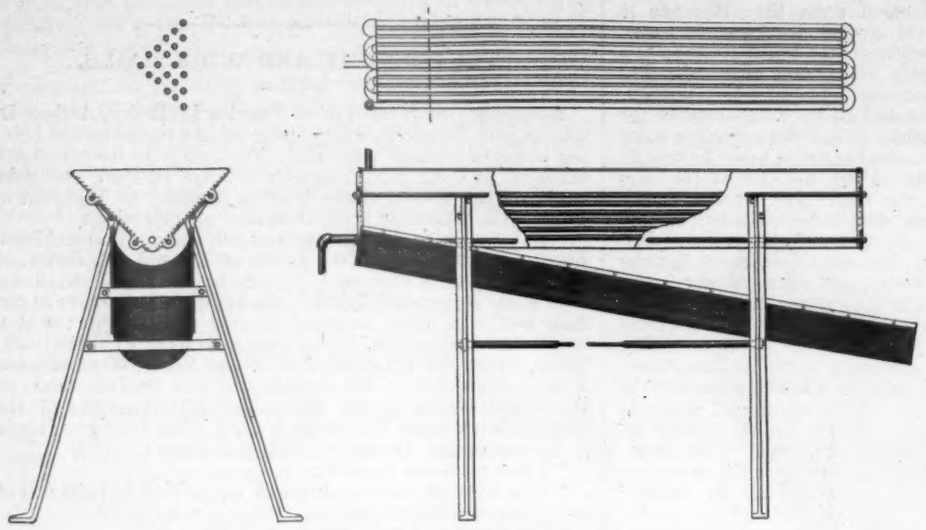
"In spruce wood, in six series of tests, comprising six sizes of box nails (longest 4 in., shortest 1½ in.), the cut nails showed an average superiority of 50.88 per cent.

"In spruce wood, in four series of tests, comprising four sizes of floor nails (longest 4 in., shortest 2 in.), the cut nails showed an average superiority of 80.03 per cent.

"In spruce wood, in above 40 series of tests, comprising 40 sizes of nails (longest 6 in., shortest 1½ in.), the cut nail showed an average superiority of 60.50 per cent.

"In pine wood, in six series of tests, comprising six sizes of

box nails (longest 4 in., shortest 1¼ in.) driven with taper perpendicular to grain of wood, the cut nail showed an average superiority of 135.20 per cent.



WILSON'S LOCOMOTIVE SAND-DRYER.

"In pine wood, in six series of tests, comprising six sizes of box nails (longest 4 in., shortest 1¼ in.) driven with taper parallel to grain of wood, the cut nail showed average superiority of 100.23 per cent.

"In pine wood, in six series of tests, comprising six sizes of box nails (longest 4 in., shortest 1¼ in.) driven in end of wood, the cut nail showed average superiority of 64.38 per cent.

"In pine wood, in above named 18 series of tests, comprising six sizes of box nails (longest 4 in., shortest 1¼ in.) driven in three ways, the cut nail showed an average superiority of 99.93 per cent.

"In spruce and pine wood combined, in the whole 58 series of tests, comprising 40 sizes of nails (longest 6 in., shortest 1¼ in.), the cut nails showed average superiority of 72.74 per cent."

LOCOMOTIVE SAND-DRYER.

THE sand-dryer which is illustrated herewith is one which has recently been brought out by George P. Wilson, of 435 North Broad Street, Philadelphia. It consists of a long trough, in which there is a coil of steam-pipe, and into which the sand to be dried is placed. As the sand dries it falls down through the spaces between the pipes and out at a small opening in the bottom, from which it drops into the inclined wire screen shown in the engraving, which separates the sand from the coarser materials and through which the former falls ready for use in the sand box of a locomotive.

The device is so simple in construction that it needs but very little explanation, and requires no special attention except to be filled with sand when necessary. The dryer is set in a bin where the dry sand is to be sorted, and as the sand dries it falls through the screen into the bin ready for use, as already stated.

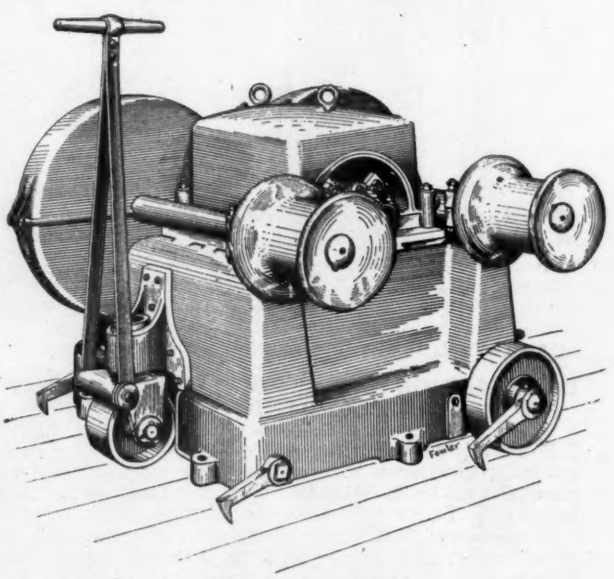
The apparatus is guaranteed to furnish dry sand for upward of 50 locomotives per day. In setting up, special precautions are taken that the steam-pipe is at the top of the coil. In outlying engine houses the steam hose of the locomotive may be attached.

THE FOUR-WINCH HOIST.

WE illustrate a four-winch electric hoist, which has recently been perfected and brought out by the General Electric Company, for use on wharves and vessels. It has been designed to meet a growing demand for a machine which will satisfy the requirements of ship and dock work. The advantages which it offers over the usual form of steam hoist is that it is more compact, lighter, and does not require the attention of a skilled engineer. It can also be used in cold weather without that waste of power which results from the use of steam, where the condensation is great, owing to exposed pipes and unjacketed radiating surfaces. There are also no leaking or bursting pipes to give trouble. The four-winch principle which it embodies enables a number of loads to be raised and lowered simultaneously.

The apparatus illustrated consists of a base frame, a motor, two shafts, each carrying two winch heads, and the necessary controlling apparatus. The frame is a strong cast-iron box, open at top and bottom, and supporting on its upper rim the motor and winch-shaft bearings, each furnished with self-oiling mechanism. The frame is provided with wheels for convenience of application. The motor is of the latest design, and is entirely enclosed by its own frame, with the exception of two small lateral openings, which allow of ready access to the brushes and armature bearings, and which are closed when the hoist is in operation. It is so set in the hoist frame as to secure a low center of gravity and great rigidity. The field coil of the motor and winding of the iron-clad armature are covered with special water-proof composition.

The winch-shafts are of large diameter steel rod, to obviate the possibility of bending under heavy loads. The winch-heads are keyed to the shafts over bronze bushings, and the difficulties which rust might create forestalled. Each winch is provided with two safety pawls, which, when the hoist is in operation, are held out of action by centrifugal force, but which immediately catch into notches provided in the bearing cap, if the current fail while a load is being hoisted. This prevents overhauling of the hoist by the load, which might otherwise happen with disastrous results. The apparatus for controlling the hoist is placed below the motor within the frame, where it is protected from mechanical injury and moisture.



FOUR-WINCH HOIST.

The particulars and dimensions of this hoist are as follows:

Four winch hoist, class 60-250, volts 110 (220) (500).

Net horse power of hoist at winches, 450 H. P.; normal speed of motor, 425 revolutions; voltage of motor, according to order, 500 volts; current at 110 volts, 360 amperes; total weight of hoist, complete, 8,000 lbs.

Lifting capacity of hoist, two weights simultaneously, 3,000 lbs; speed of lifting, 250 per minute; diameter of winch-heads, 12 in.; length of winding space on winch-heads, 9½ in. Over all dimensions of hoist are as follows: Length, 6 ft. 10 in.; width, 6 ft. 7 in.; height with wheels, 4 ft. 7½ in.; height without wheels, 4 ft. 5½ in.